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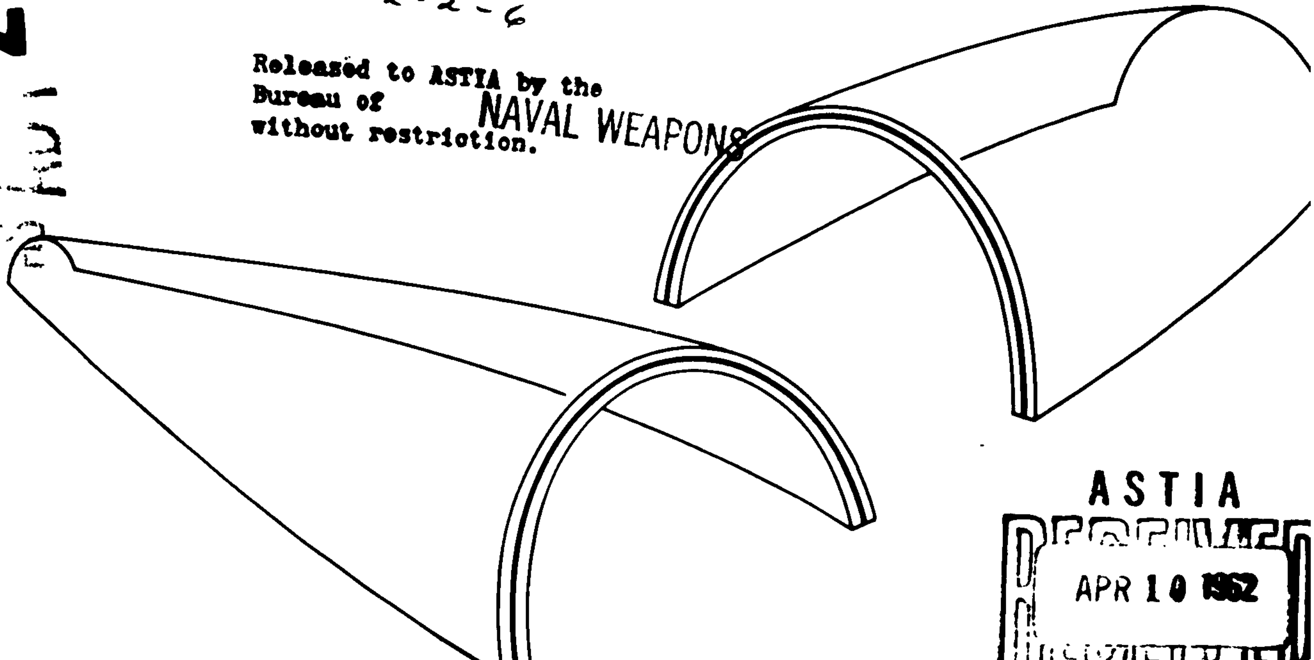

GOODYEAR AIRCRAFT CORPORATION

AKRON 15, OHIO

Goodyear Engineering Report GER 10613

GOODYEAR

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AKRON, OHIO

EVALUATION OF HIGH-TEMPERATURE CAST-IN-PLACE TRANSPARENT PLASTIC LAMINATES SUITABLE FOR CANOPIES ON SUPERSONIC FIGHTER AIRCRAFT

Prepared under Bureau of Naval Weapons
Contract NOa(s) 59-6146-C

Quarterly Progress Report No. 9

9 November 1961 through 8 February 1962

Goodyear Aircraft Corporation
Akron 15, Ohio

BY:

APPROVED.

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FOREWORD

During May, 1961 all work on this program was stopped and placed on a "stop hold" status because of funding limitations. Work was discontinued for approximately 5 months and the "Stop hold" was not cancelled, allowing work to be resumed, until mid-November, 1961. This, then, is the first report since May, 1961 on the program status and covers all work accomplished since November 1961 when work was resumed.

ABSTRACT

The purpose of this three-phase program is to evaluate the Goodyear Aircraft Corporation developed THERMO-SHIELD* concept for a high-temperature resistant transparent plastic laminate possessing a cast-in-place interlayer material. The THERMO-SHIELD laminates under evaluation in this program are of three-ply construction with a 0.250-inch thick load-bearing face sheet of stretched MIL-P-8184 (Plexiglas 55**), a 0.125-inch thick castable interlayer designated Goodyear Aircraft Corporation code F-3 interlayer, and a 0.250-inch thick thermal-barrier face sheet. Materials under consideration as possible thermal barriers in the early part of the program included "regular grade" and "laminating-grade as cast" MIL-P-8184A (Plexiglas 55)[1], Sierracin 880***, Sierracin 890 ***, Selectron 400 ****, Polymer K **, plate glass, an epoxy material developed by Midwest Research Institute, polycarbonate, and Corning Glass Works' Code 1723 high-temperature, low expansion glass. Phase I screening tests reduced the field of potential thermal barriers to "laminating-grade as cast" Plex 55 and epoxy, both being nearly equal in performance. However, because the epoxy material is still in the developmental stage, "as cast" Plex 55 has been selected as the thermal-barrier material for Phase III testing.

The optical and fabrication feasibility study of full-scale THERMO-SHIELD canopies was successfully demonstrated in Phase II of the program.

During the work period just ended, the entire Phase III test setup was finished, all pilot testing to check out test equipment and test procedures was performed and the first gradient temperature destruction test on a full scale THERMO-SHIELD canopy was completed with very successful results. A boundry layer air temperature of 455°F with an associated canopy outboard thermal barrier outer surface temperature of 400°F was reached before the initial failure was experienced.

The canopy was pressurized throughout the test at 8.6 psi and the outboard thermal barrier was above 260°F (boundry layer air above 310° F) continuously for $6\frac{1}{2}$ hours before a delamination type failure at the thermal barrier to interlayer interface, occurred at 400°F outboard surface temperature.

*TM, Goodyear Aircraft Corporation
** TM, Rohm and Haas Co.
***TM, Sierracin Corporation.
****TM, Pittsburgh Plate Glass Company
1 - MIL-P-8184 material (Plexiglas 55) either stretched or "as cast", is hereafter referred to as Plex 55

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SECTION I - INTRODUCTION

This is the ninth progress report in a program to evaluate high-temperature cast-in-place transparent plastic laminates suitable for canopies on supersonic fighter aircraft. The program is divided into three sections as follows:

Phase I - Thermal and structural evaluation of proposed material composites

Phase II - Fabrication feasibility study

Phase III - Full-scale evaluation testing of components produced in Phase II.

Phase I of the program was concerned with the thermal and structural evaluation of different types of THERMO-SHIELD* composites. Each type of composite was of three-ply construction with the following make-up:

1. The 0.250-inch thick load-bearing face sheet common to all test composites was hot-stretched, crack-propagation resistant, transparent plastic, conforming to Specification MIL-P-8184A prior to hot-stretching, with an initial minimum toughness ("K" factor) of 2500 lb/in.$^{1.5}$ at 73.5°F.
2. The 0.125-inch thick interlayer common to all test composites was GAC code F-3 interlayer, a transparent flexible, high-temperature resistant castable resin system.
3. The thermal barrier face sheet was varied for each different type of

*TM, Goodyear Aircraft Corporation Akron Ohio

test composite for screening and evaluation purposes. All thermal barriers were .250" thick, with one exception which is noted. Potential thermal barrier materials tested are listed below:

a. Sierracin 880

b. "laminating-grade as cast" MIL-P-8184

c. "regular grade as cast" MIL-P-8184

d. Plate glass

e. Sierracin 890

f. Selectron 400

g. Polymer K (.200" thick)

In addition to the thermal barrier face sheets listed, three other potential thermal barrier materials, only recently available, were given preliminary Phase I screening. These materials were (1) Midwest Research Institute's high-temperature epoxy formulation, (2) Corning Glass Works' code 1723 high-temperature alumino-silicate glass, and (3) polycarbonate extruded sheets.

All Phase I testing has now been completed, with Epoxy and MIL-P-8184A "laminating grade" as cast sheet being the only two thermal barrier materials to successfully withstand the rigors of all screening tests. Because the epoxy material is still in the developmental stage and cannot be obtained in large enough sheet sizes to fabricate the Phase III test canopies, "laminating grade as cast" Plex 55 was selected for use as the thermal barrier face sheet of the THERMO-SHIELD canopies to undergo Phase III static testing.

Phase II of the program encompasses a fabrication feasibility study of full-size prototype THERMO-SHIELD canopies and windshield side panels of McDonnell F-4H design. Thus far, it has been demonstrated that full scale canopies can be laminated with acceptable optical quality.

Phase III involves the static testing of three of the optically satisfactory full size canopies which were laminated in Phase II.

The types of tests planned in Phase III are (1) two gradient temperature destruction tests and (2) a long time cyclic test.

To date, one of the two gradient temperature destruction tests has been completed. Initial test results indicate that the THERMO-SHIELD Canopy concept will be capable of withstanding gradient temperature conditions some what higher than anticipated.

SECTION II - PROGRESS COMMENTARY

9 November 1961 thru 8 February 1962

Phase I Commentary

A. GENERAL DISCUSSION

The last portion of Phase I testing was completed and the associated test data presented in progress report No. 8 (reference GER 10379).

Phase II - Part I Commentary

Canopy Fabrication Feasibility Study

A. GENERAL

The crazing problem which was discussed in report No. 8 has been solved and eliminated. All Phase III test canopies have now been laminated and fabricated, and the results reported herein conclude the canopy fabrication portion of Phase II.

B. CHRONOLOGICAL HISTORY OF CANOPIES LAMINATED IN PHASE II (Continued from GER 10379, pages 10 through 15)

For a period of time while the program was on "stop hold", small castings were attempted on a laboratory basis in an effort to solve the crazing problem and at the same time conserve material. However, despite numerous attempts, the crazing phenomenon experienced in the full size canopies could not be simulated or reproduced in the laboratory castings. Because of these laboratory results, it was concluded that the crazing phenomenon was peculiar to the size, shape, and contour of the full size canopy and windshield scale panel, and therefore the laboratory size castings were necessarily terminated.

Immediately upon resumption of work in mid-November, the annealing temperature and cycle used on the No. 4 canopy were experimentally varied and the No. 5 canopy was laminated. Crazing again developed. The No. 3 windside panel also crazed after still another annealing variation. However, the next change in annealing procedures, coupled with a change in method of support of the side panel during the interlayer cure cycle, resulted in the No. 4 side panel being laminated with no sign of crazing. The annealing temperature, cycle and method of support used on the No. 4 side panel were then duplicated on the No. 5 side panel and again no sign of crazing occurred. Again repeating the same annealing temperature, cycle and method of support, the No. 6 canopy was successfully laminated without crazing.

Crazing developed again in the No. 7 canopy, even though all pertinent processing associated with the No. 6 canopy was thought to be exactly duplicated (later proved not to be the case.) The No. 8 canopy was free from crazing with the exception of one small area which developed crazing in the top or crown section of the canopy at the point of maximum draw.

It was discovered at this point that in spite of exactly duplicating annealing procedures and method of support on the No. 6, 7 and 8 canopies and No. 4 and 5 side panels, the processing time between final annealing and laminating had been inadvertently and significantly increased on the No. 7 canopy. This was also true for the No. 8 canopy, but to a much lesser degree, with a corresponding reduction in the amount of crazing

which resulted. By using the processing time associated with the No. 6 canopy between annealing and laminating and by again using the No. 6 canopy annealing temperature and cycle, both the No. 9 and No. 10 canopies were laminated successfully without crazing. Laminating of canopies was terminated at this point, as the required number of canopies for test purposes had been fabricated. A tabular account of the canopies laminated in Phase II is seen in Table I.

Table I - Chronological History of Laminated Canopies

Serial No.	Condition	Optical condition with respect to grid line distortion & deviation	Remarks
1.	Crazed	Marginal	Cut into pieces for interlayer thickness check
2.	Did not craze	Reasonably good except for "buckles" at side rails	Cut into pieces for interlayer thickness check
3.	Crazed	Good - Slight band distortions in forward & aft hoop areas	
4.	Crazed	Good - Slight band distortions in forward and aft hoop areas	Destroyed in pilot testing
5.	Crazed	Good	Used to complete pilot testing
6.	Did not craze	Meets requirements of McDonnell optical spec.	To be used for second half of gradient temperature destruction test starting at 300°F
7.	Crazed	Meets requirements of McDonnell optical spec. except for crazing	Cut into pieces for interlayer thickness check
8.	Slight crazing	Meets requirements of McDonnell optical spec. except for crazing	Used for first half of gradient temperature destruction test starting at 260°F
9.	Did not craze	Meets requirements of McDonnell optical spec.	To be used for long time cycle test
10.	Did not craze	Meets requirements of McDonnell optical spec.	Back up canopy for either destruction test or cycle test

C. OPTICAL QUALITY OF THERMO-SHIELD CANOPIES

The optical quality of the No. 6 thru No. 10 canopies was very good and can be considered to be slightly better than the optical quality reported previously for the No. 3 and No. 4 canopies.

However, even though the test canopies are optically acceptable from a distortion and deviation standpoint, it should be realized that the optical quality of laminated transparencies must necessarily be somewhat inferior to that of a similar monolithic transparency because of thickness variation within the laminate and also because the indices of refraction of the laminate face sheets and interlayer are not matched.

Three of the crazed canopies were cut into sections after laminating to determine the uniformity of the F-3 interlayer thickness. It was found that the interlayer thickness increased progressively toward the center area of each canopy. Checks of the air gap between these canopy shells before laminating indicated a rather uniform nominal thickness of .125". Since the thickness of the interlayer after laminating had gradually increased to at least .200" in the crown area of the canopy, it is reasoned that the hydrostatic head created by the interlayer resin during laminating caused the unrestrained canopy shells to spread apart during the cure cycle in direct proportion to the variation in hydrostatic head at different levels in the canopy. Also contributing to the problem is the fact that the modulus of the Plexiglas 55 shells decreases slightly at the interlayer curing temperature, thus making the shells more succeptable to deflection under the pressure forces of the hydrostatic head.

Even though optics in the canopies are very good, particularly in the side areas, it is felt that optical quality has been reduced in the upper side and top areas of the canopies because of the gradual increase in interlayer thickness toward the top centerline. This increase in interlayer thickness can be eliminated, however, should the optical requirements of the part in question demand it.

All canopies in this feasibility study program were laminated without the aid of any tooling casting fixtures or special laminating equipment. By utilizing matched male and female holding fixtures with an indexing system to control interlayer thickness during the laminating operation, the varying interlayer thickness due to the hydrostatic resin head could be virtually eliminated. Such laminating tooling would be well within the state of the art, being nothing more than a female forming fixture with a male plug cast from the female mold surface. Such a system would control interlayer thickness precisely and should result in laminated parts of excellent optical quality.

Phase II - Part II Commentary

Windshield Side Panel Fabrication Feasibility Study

The laminating history of five windshield side panels has been briefly mentioned in relation to the crazing problem. In no case has a laminated side panel even approached the degree of optical quality required for a panel with such stringent optical requirements (79° angle of incidence from pilot's eye position). However, the optical quality of the assembled side panels prior to the laminating operation has been for the most part within acceptable limits.

Interlayer thickness checks after laminating have revealed even more extreme increases in the interlayer thickness than was the case with the canopies. It is a virtual certainty that the optical quality required for a laminated side panel cannot be achieved without the aid of a laminating fixture (such as described for use with the canopies) to precisely maintain a uniform interlayer thickness.

To verify this supposition, one more side panel will be laminated to complete this portion of Phase II. However, it will not be "laminated" in the strict sense associated with castable interlayers. A sheet of cured F-3 interlayer of uniform thickness has been prepared for insertion between two side panel shells to form a three ply sandwich. Tests in the past on experimental panels prepared in a similar manner have shown that a pseudo type adhesion can be obtained between the outer face sheets and F-3 interlayer sheet by subjecting the sandwich to the F-3 interlayer curing temperature and at the same time

applying vacuum and autoclave pressures of 20 psi. Although the resulting interlayer adhesion to the face sheets is inadequate for structural purposes, such laminates can be used for optical studies.

Therefore, if this technique can be applied successfully to the side panel, it should be possible to optically evaluate a side panel with a uniform interlayer thickness. In this manner it could then be rationalized whether or not laminating fixtures could be employed to precisely control the F-3 interlayer thickness to achieve a THERMO-SHIELD side panel with acceptable optical quality.

Phase III Commentary

Full-Scale Static Testing of the Forward Canopy Configuration

A. GENERAL

The setup of all test facilities and test instrumentation was recently finished. Pilot testing was then accomplished and Test No. 1 was completed just prior to the close of the work period. The following discussion pertains to the details of the test setup, instrumentation, test procedures, pilot testing, Test No. 1, data reduction and a brief analysis of initial test results.

B. TEST FACILITIES

The setup of the test oven and refrigeration equipment described in report No. 8 was completed soon after the start of the report period. The crazed No. 4 canopy was trimmed and fabricated for pilot test purposes so as to avoid damaging a good test canopy if anything should go wrong during initial test equipment and systems checkout. After extensive preliminary checkout and testing of all equipment, it became apparent that the heat exchangerunit for the test oven did not have sufficient capabity to attain the required test temperatures. At the time the test oven was designed, this heat exchanger unit had been available and was, by engineering analysis, rated at sufficient capacity (BTU's/hr) to provide the heat flux and temperatures required by Phase III test specifications. However, in the actual test setup, heat losses from convection and from hot air expansion in the heat transfer ducting to the test chamber resulted in insufficient boundry layer air at the canopy to raise the outboard thermal barrier surface of the canopy to the required test temperatures. Attempts to correct the situation were unsuccessful and it was decided to move the test setup into an existing oven (of proven high temperature capabilities) which was made available by necessity in the GAC Plastics production area. The canopy interior refrigeration system and the entire instrumentation system of thermocouple recorders, strain gage oscillograph recorders, power supplies and bridge balance boxes were moved intact to the new test area. The new test oven was modified to accommodate the strain gage compensating window, observation windows and the ducting for the refrigeration

equipment. The new setup, after relocation, is seen in Figures 1 and 2. The new test oven is capable of attaining temperatures of 500°F and has a burner output rating of 500,000 BTU/hr.

A five horsepower circulating fan supplies 10,500 cubic feet of air per minute (CFM) to the oven chamber which is 10 feet wide, 15 feet long and 7 feet high. The oven air velocity approximately 1 inch from the canopy surface has been measured by means of an anemotherm and found to be in the range of 120-250 feet per minute (FPM).

A zone check of the empty oven chamber established that a uniform temperature distribution existed within the oven of ± 2°F over the temperature range from 100°F to 500°F.

C. REFRIGERATION SYSTEM FOR INTERNAL CANOPY AIR

The purpose of this cooling system is to maintain the closed system internal air at a temperature which would simulate actual high speed (Mach 2.5+) flight conditions. The capacity of the system was determined by thermodynamic calculation to maintain the inlet air at an h_{si} (internal surface heat removal rate) which would match known conditions of high performance aircraft. The resulting test data has demonstrated the suitability of the refrigeration system.

The mechanical refrigeration system for the inside air of the canopy consists of an air compressor and evaporator coils. Refrigerated air is circulated thru the canopy at approximately 390 FPM and 76 CFM. The cooling system is of the recirculating type and thus is pressurized to 8.6 psi while in operation as a result of the canopy itself being pressurized.

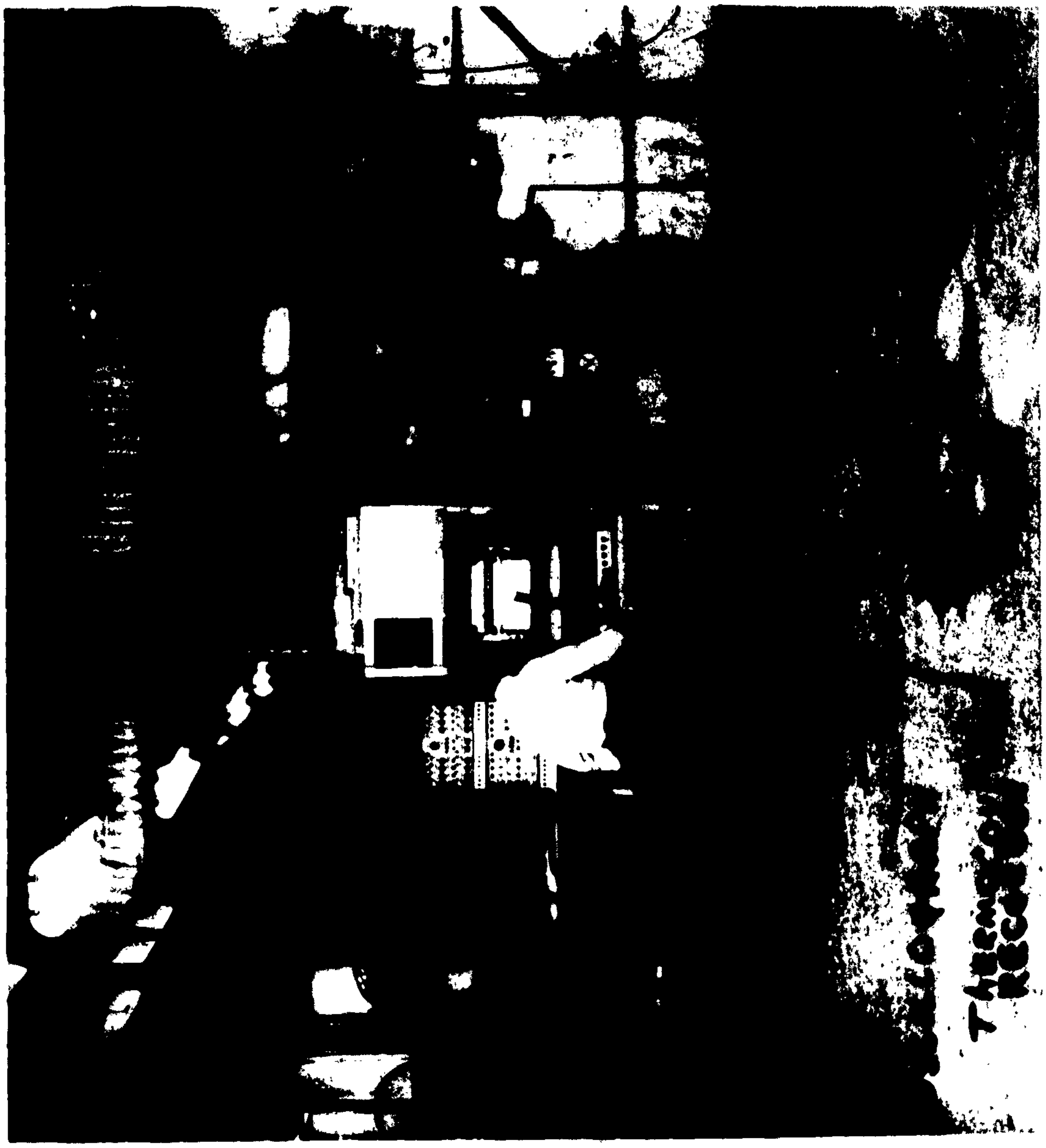


Figure 1. Phase III Test Equipment Setup

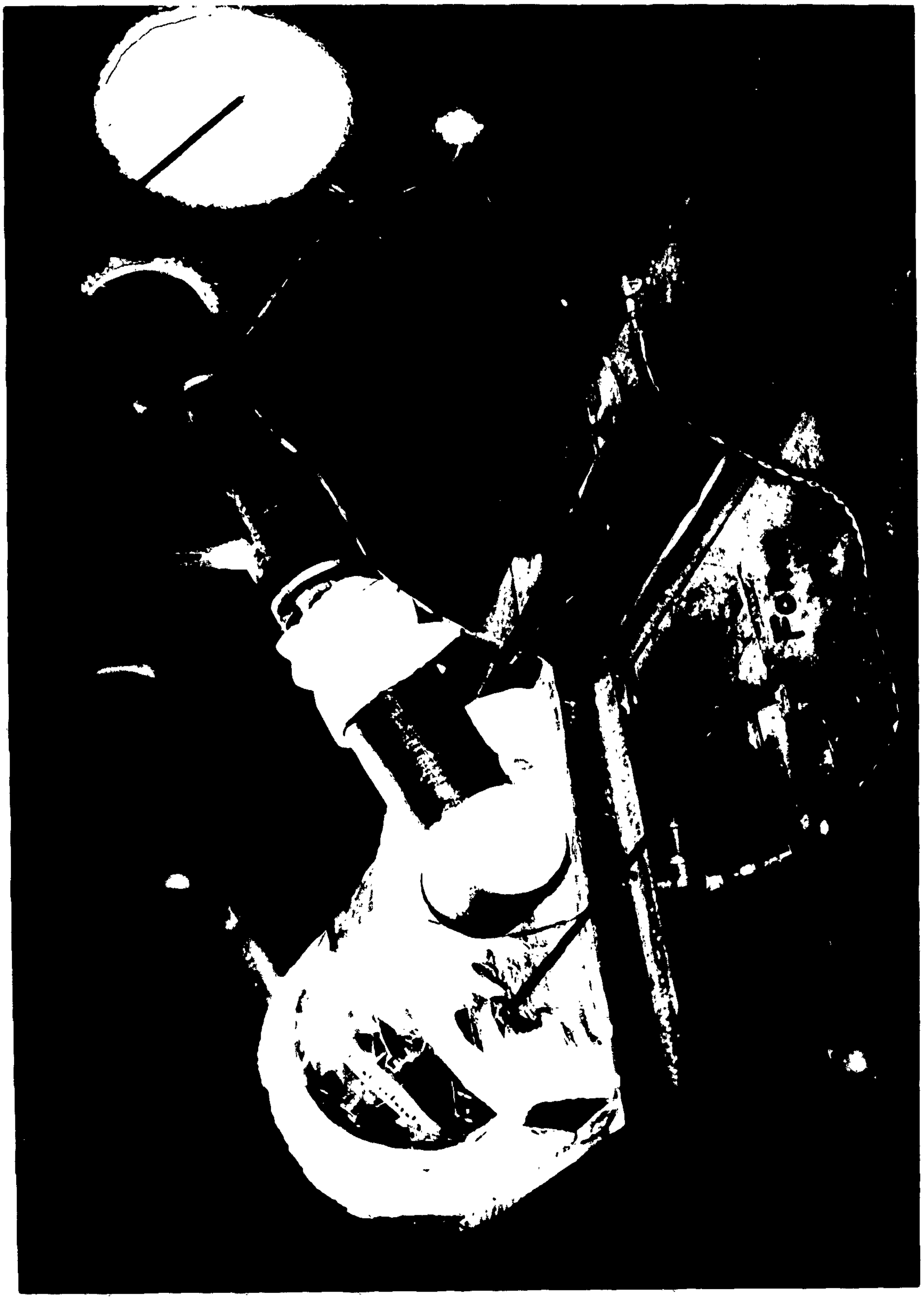


Figure 2. Canopy Test Stand In Place In Test Chamber

The pressurization system is controlled by a differential pressure controller and a solenoid pressure relief valve to prevent accidental overpressuring of the canopy and refrigeration system.

D. TEST STAND

The canopy test stand, complete with a canopy installed and instrumented, was seen in Figure 2. The bulkheads of the test stand have been insulated with Fluro-Carbon blown Polyurethane foam and the side rail and hoop areas of the canopy have been faired in with asbestos insulating cement. The access manhole in the bottom of the test stand is also covered with insulation during testing, as are the inlet and exhaust refrigeration ducts leading into the test stand bulkheads. Provisions have been made to slowly circulate cold water through the base of the test stand to prevent the side rail edge attachment from overheating during testing and, thus simulate the heat sink of a typical canopy frame and airplane structure. Instrumentation wiring inside the pressurized canopy and refrigeration system has been routed through the refrigeration ducting and exits to the recording equipment through a potted, pressure tight seal. External instrumentation wiring is routed thru an insulated hole in the oven wall directly below the strain gage compensating window. (not shown in Figure 2. Window was replaced with insulation for Pilot testing).

E. TEST CANOPIES

As mentioned previously, all canopies required for Phase III testing have been laminated. These units have been trimmed to size, routed, and all edge attachment holes drilled per drawing 61QS281 (reference GER 10379, p 31). All test canopies have been fully strain gaged and wired, including the No. 9 cyclic test canopy and No. 10 backup canopy.

A test canopy (No. 9) is seen in Figure 3, immediately prior to installation and bolting into the test stand. Close observation of Figure 3 will show:

(1) The right side thermal barrier clamping plates in position (note forward, center and aft cutouts at top edge of plates to allow cantilever arms on the linear motion potentiometers to extend under the edge of the thermal barrier cutback.

(2) Step rout in as cast Plex 55 thermal barrier where aluminum hoops and loading straps fit (reference GER 10379 pages 33 and 34).

(3) Elongated holes in lower side rail (center two are circular) for slotted edge attachment inserts and bolts.

(4) Small circular holes in side rail above elongated holes where thermal barrier clamping plates bolt to canopy.

(5) Orientation of the Baldwin type PA-3 strain gages at the forward, center and aft hoop sections.

(6) Orientation of the Baldwin type PA-3 strain gages in the longitudinal direction along the side rail.

Due to excessive air leakage during pressurization to 8.6 psi, the rubber diaphragm used to seal off all openings around the side rail bolt holes and hoops was discarded in favor of a pressure sealing compound (Thiokol type- Proseal PR-1221). All large openings are first filled with zinc

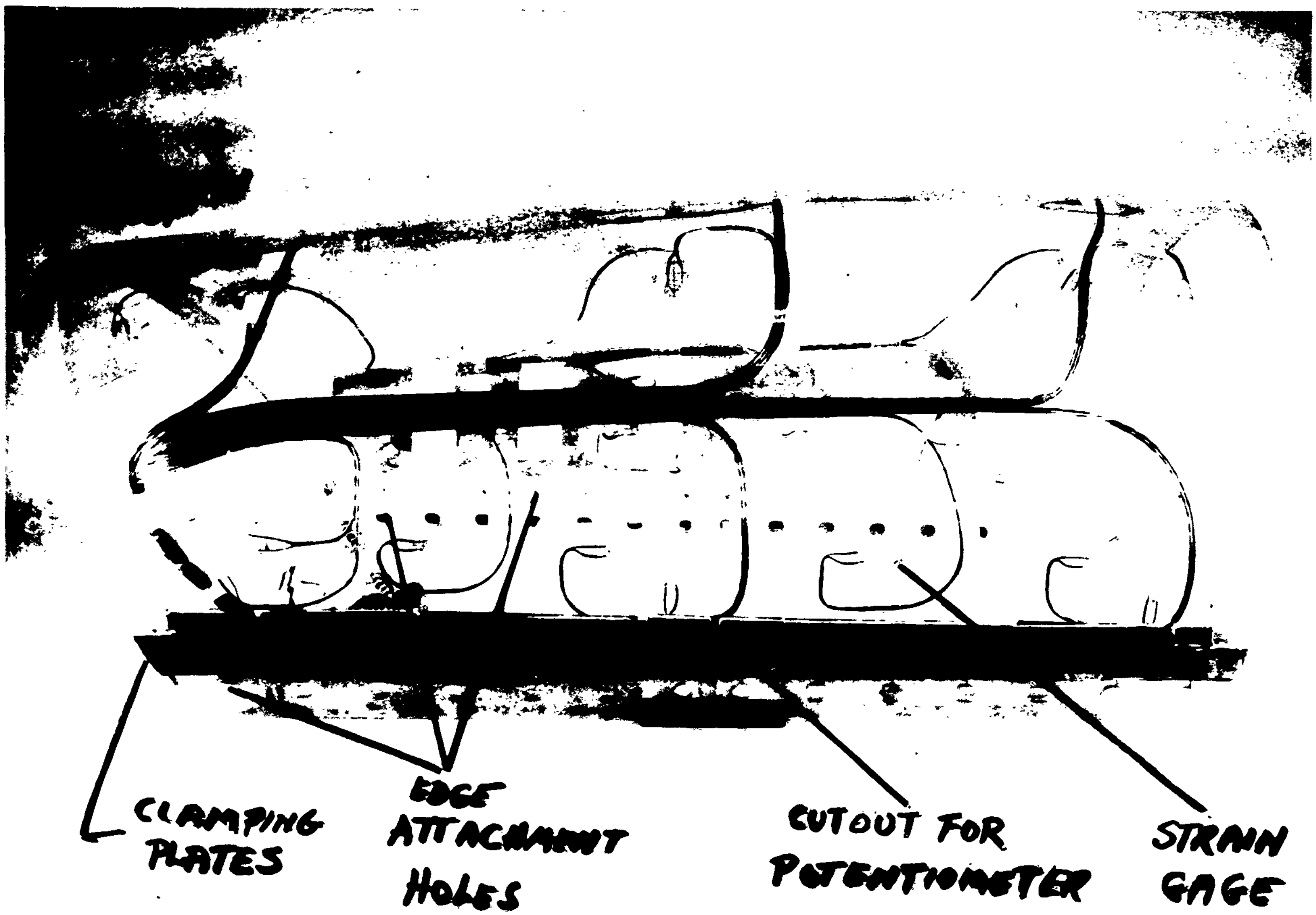


Figure 3. THERMO-SHIELD Test Canopy ready for Installation in Test Stand

chromate sealing putty. Pro-Seal PR-1221 sealing compound is then applied over the zinc chromate putty and all other openings to completely seal any openings which could cause leakage and loss of pressure during testing. This sealing system has been satisfactorily used on all testing performed to date.

F. INSTRUMENTATION

The instrumentation system consists of recording equipment to monitor and permanently record temperatures, deflections and strains of the test canopies.

(1) Temperatures are recorded at 100 different points by means of No. 30 gage iron-constantan thermocouples on a Brown Automatic temperature recording system. A complete sequence of 100 readings can be recorded in 2½ minutes by the system.

(2) Canopy deflections (normal to the surface) are measured by the cantilever beam method. The cantilever beams utilize strain gages which are externally powered by precision bridge power supplies. Signals are subsequently routed through a network of bridge balance boxes, with the output signals being recorded on light sensitive film in an oscillograph. The film is then developed and the data reduced. A block diagram type schematic of this portion of the instrumentation is seen in Figure 4.

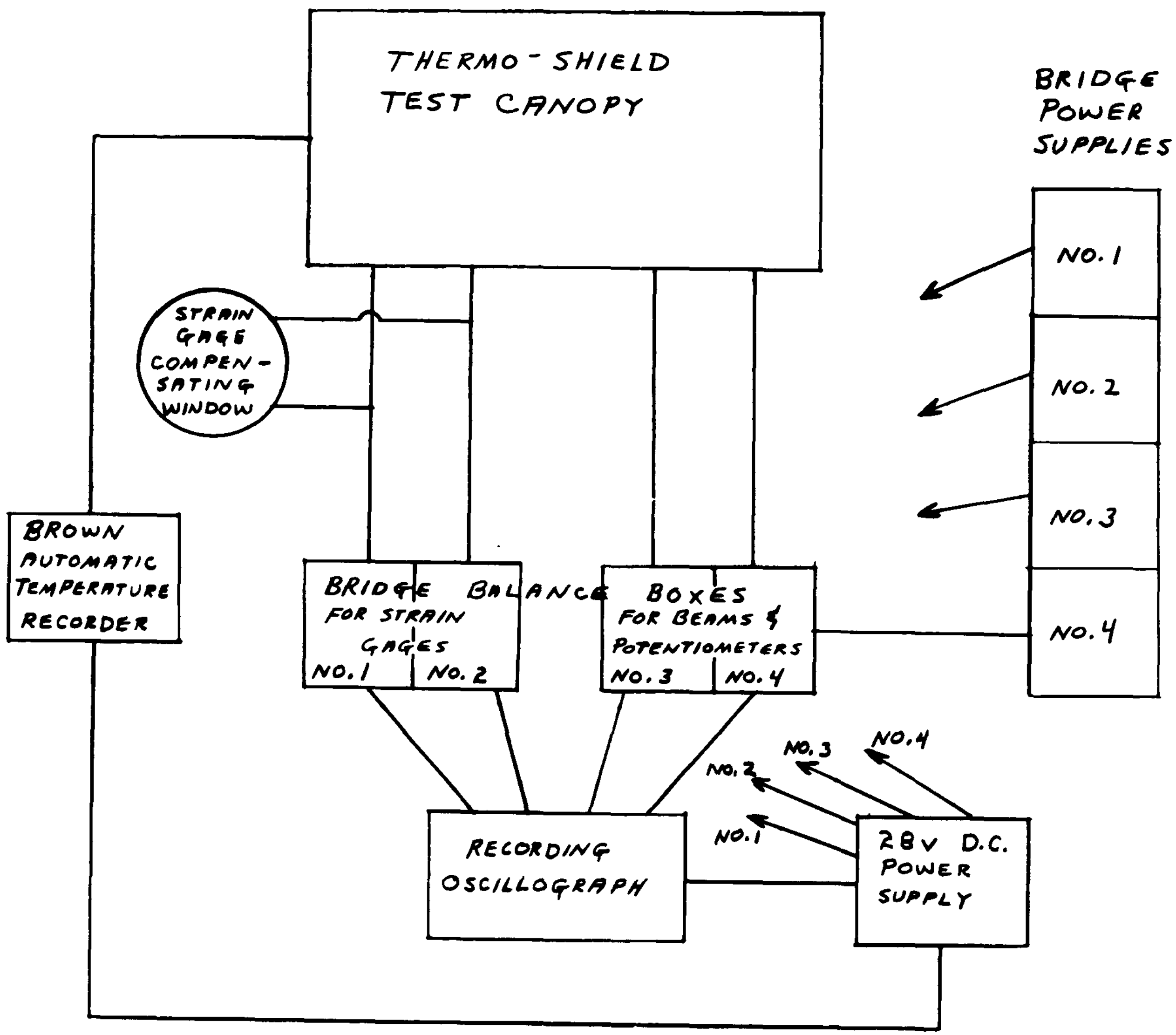


Figure 4. Phase III Canopy Instrumentation Block Diagram

(3) The strain gage readings are accomplished by using Baldwin type PA-3 post yield strain gages. The gages are electrically bridged and the output signals routed in the same manner as described above in item (2) for canopy deflections. Other details pertaining to the exact location points of all instrumentation, etc. were presented previously in GER 10379, pages 42-44.

Several of the cantilever beams used for measuring deflections can be seen in Figure 5. The beams are clipped to the supporting bridge structure by means of small c-clamps. After a test canopy has been installed and bolted in place, the bridge support structures are raised thru the access manhole and secured in place to the base of the test stand. The individual cantilever beams are then clipped in place, plugged into the electrical junction cables, adjusted to the canopy surface to ensure the proper amount of spring tension on the canopy surface and then calibrated. Also shown in Figure 5 are three of the six linear-motion potentiometers used to measure vertical displacement of the "as cast" Plex 55 thermal barrier shell with respect to the base of the test stand.

Figure 6 is similar to Figure 5, except that a canopy has now been placed in the test stand to show the relative positions of the instrumentation with respect to the canopy surface. Note the cantilever arms on the linear-motion potentiometers extending under the edge of the "as cast" Plex 55 thermal barrier.

Figure 5. Test Stand Showing Cantilever Beam Deflection Instrumentation

Figure 6. Test Stand With Canopy and Instrumentation in Position

Figure 7 shows the canopy bolted in place in the test stand with all asbestos insulation faired in place. The hoop loading straps are beneath the faired insulation and cannot be seen. Three cutouts have been provided in the side rail insulation for access to the linear-motion potentiometers. A baffle for distributing refrigerated air flow within the canopy can also be seen near the center of the canopy.

Figure 8 is a view through the observation window in the test oven during the latter stages of Test No. 1 (gradient temperature destruction test) when the canopy outboard surface was at 380°F. All instrumentation can be seen, including thermocouples and the forward, center and aft hoop baffles for internal air distribution.

G. TEST SPECIFICATION FOR TEST NO. 1 - GRADIENT TEMPERATURE DESTRUCTION TEST

All test requirements and conditions have been previously discussed and outlined in progress report No. 7 (reference GER 10378, pages 15 thru 18). However, it is the purpose of this section to review all pertinent test requirements and conditions in order to gain a clearer understanding of the discussion to follow pertaining to the results of pilot testing and Test No. 1.

During a meeting held on January 17, 1961 at GAC between BuWeps and GAC personnel, the following general outline of procedure was established for Phase III testing:

(1) Goodyear Aircraft Proposal (GAP) 8225 remains the basic program guide for Phase III testing.

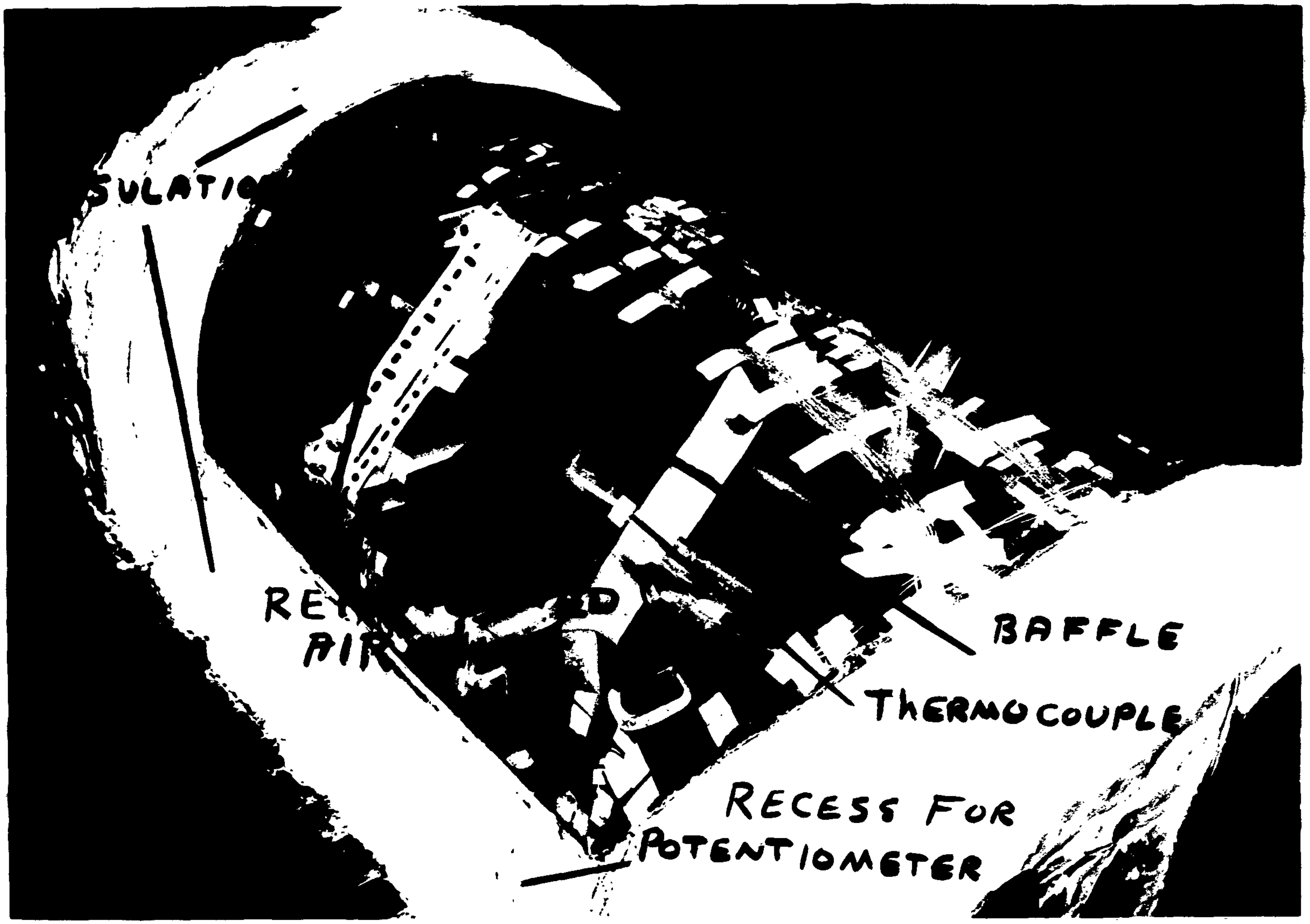


Figure 7. Test Stand and Canopy ready for Phase III Testing

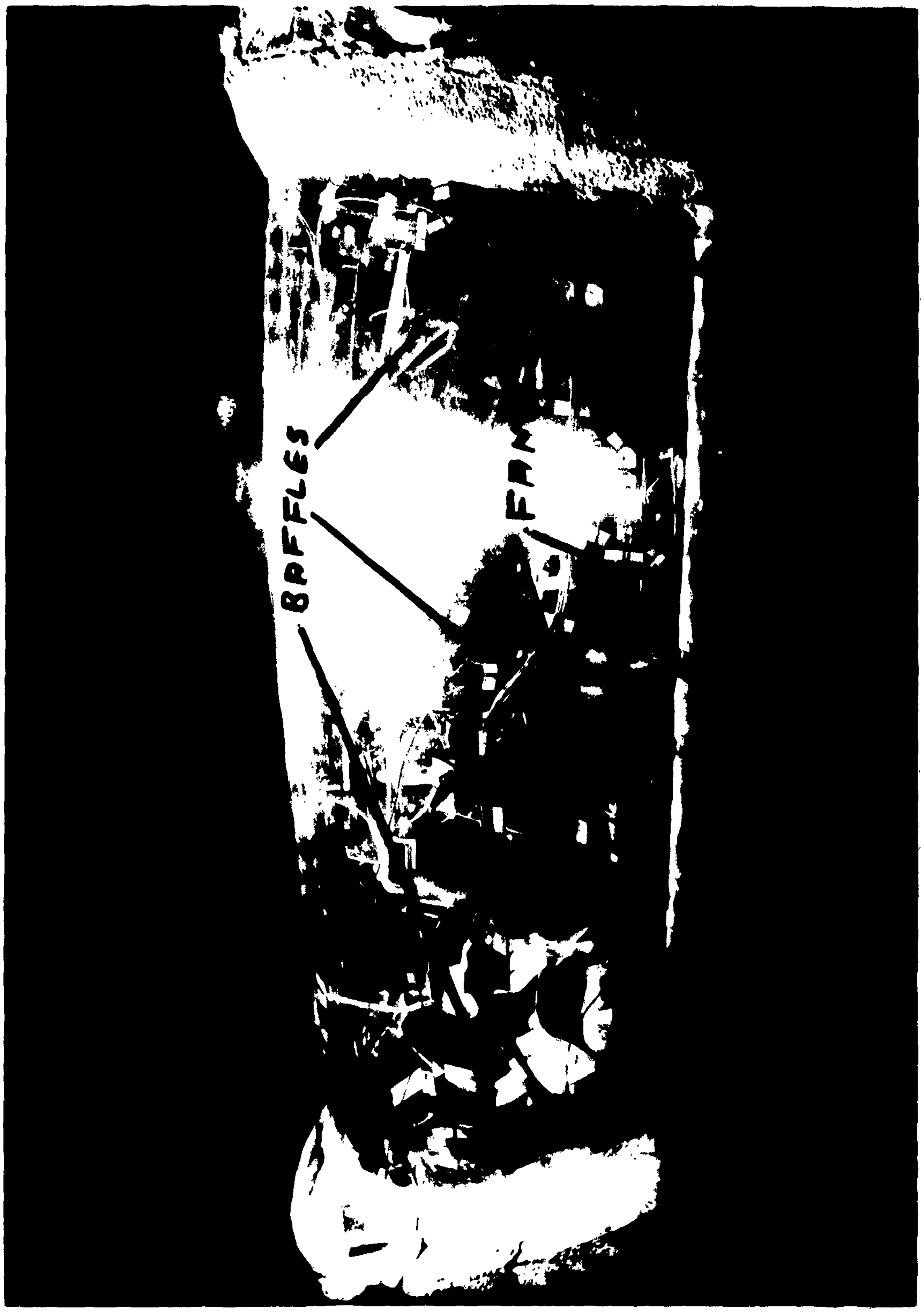


Figure 8. Fully Instrumented THERMO-SHIELD Canopy Undergoing Test at 380°F

(2) 0.250-inch thick "laminating-grade as cast" Plex 55 will be used for the outboard thermal barrier material for all test canopies. This decision was based on NRL wind tunnel tests (reference GER 10378, page 9) and the comprehensive Phase I evaluation screening tests conducted by GAC.

(3) Though GAP 8225 states that only two canopies will be tested, BuWeps and GAC personnel concur that testing may involve three or four canopies instead of two.

(4) Requirements for Test No. 1 - Gradient Temperature Destruction Test

The purpose of test No. 1 is to determine the apparent limiting temperature gradient at which a THERMO-SHIELD canopy can sustain short-time applications of limit load without failure. The test will consist of stabilizing the canopy at successively higher temperatures while under limit load for 20 minutes at each temperature. Failure will be determined by visual observation of such phenomena as delamination, crazing, interlayer cracking, material shrinkage or "shrink back", yellowing, orange peel, etc. The three percent material creep limitation suggested by GAP 8225 will not apply, principally because it has been determined that this parameter cannot be measured accurately under the specified test conditions and with existing test instrumentation. Likewise, midplane or interlayer temperature control as suggested by GAP 8225 will not apply. Instead, inboard and outboard temperatures will be controlled and interlayer temperatures will be computed. Other test details will be as follows:

(a) Outboard or thermal-barrier surface temperature will be stabilized successively at temperatures of 260°F, 270°F, 280°F, 290°F, 300°F, 310°F, - - - to failure.

(b) Inboard surface temperature will be maintained throughout the entire test at approximately 130°F and will not exceed 160°F. The 160° temperature may be encountered due to the natural temperature gradient at the higher test temperatures.

(c) The temperature of the edge attachment area will be controlled at approximately 110°F and is not to exceed 130°F.

(d) Cockpit air pressure will be 8.6 psi.

(e) The canopy will be stabilized successively at each temperature and held for 20 minutes at 8.6 psi and limit load. The canopy will be de-pressurized after the required time at each test temperature, and deflection readings, etc. will be recorded before the temperature is raised to the next increment. The canopy will not be returned to room temperature until failure occurs.

(f) Strain gage transducers will be used to measure deflections on the inside of the canopies at forward center and aft hoop sections.

(g) Strain gage readings will not be recorded on the outside of the canopies because of the temperature limitations of available strain gages. On the inside of the canopies, the strain gages will not be exposed to temperatures above 160°F and can, therefore, be cemented to the inside surface of the stretched Plex 55.

Strain gages cemented to the outside surface could be the source of premature failure at the high test temperatures expected.

(h) Temperature readings will be taken by means of thermocouples at all points of instrumentation and also at any other points of specific interest.

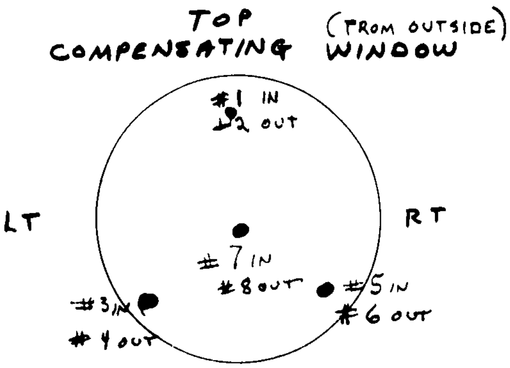
(i) Strain and deflection readings, etc. will also be recorded after completion of cycling until the canopy and test stand have cooled to room temperature.

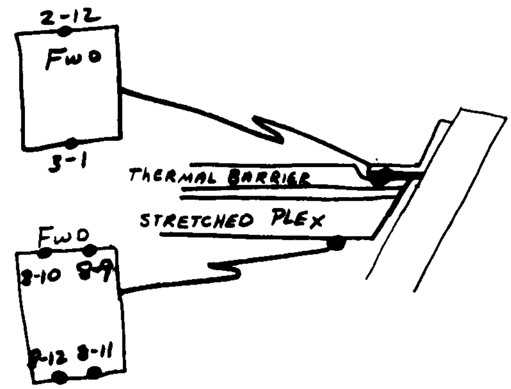
H. PILOT TEST HISTORY - TEST NO. 1 - GRADIENT TEMPERATURE DESTRUCTION TEST (NO. 5 THERMO-SHIELD CANOPY)

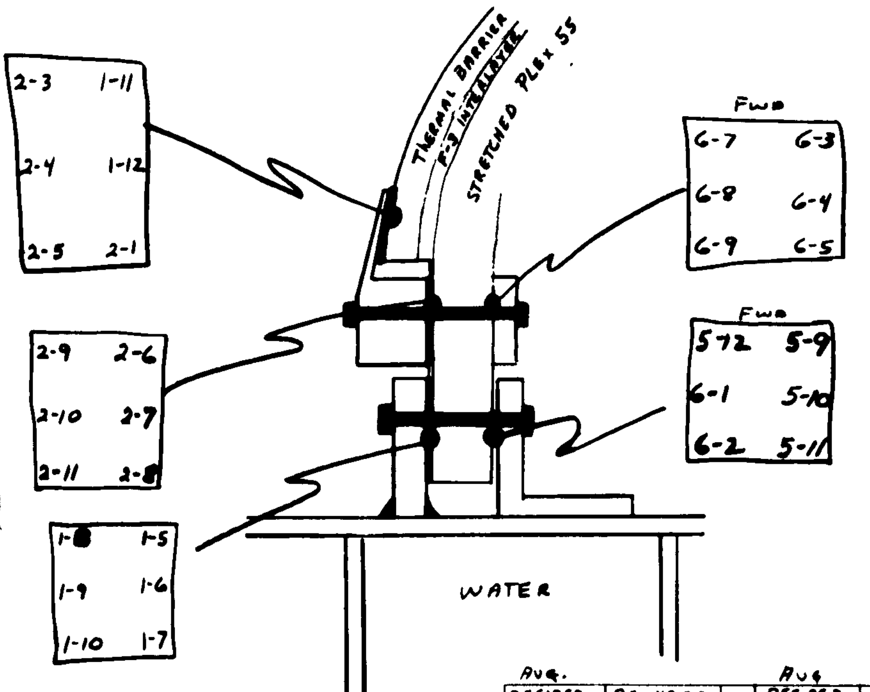
Figure 9 shows the position, relative location, and identification code of all thermocouples which will be monitored in Test No. 1 and the long time cyclic test.

After determining that the canopy could be successfully pressurized to 8.6 psi without significant leakage, pilot testing was commenced. Instrumentation for this test was limited to the complete thermocouple monitoring system and one longitudinal row of strain gages along the top centerline of the canopy.

Runs No. 1 thru 14 on the No. 5 pilot test canopy were performed over a period of several days to "bug out" and become familiar with the functionality of the test setup, oven and refrigeration characteristics, and instrumentation performance.







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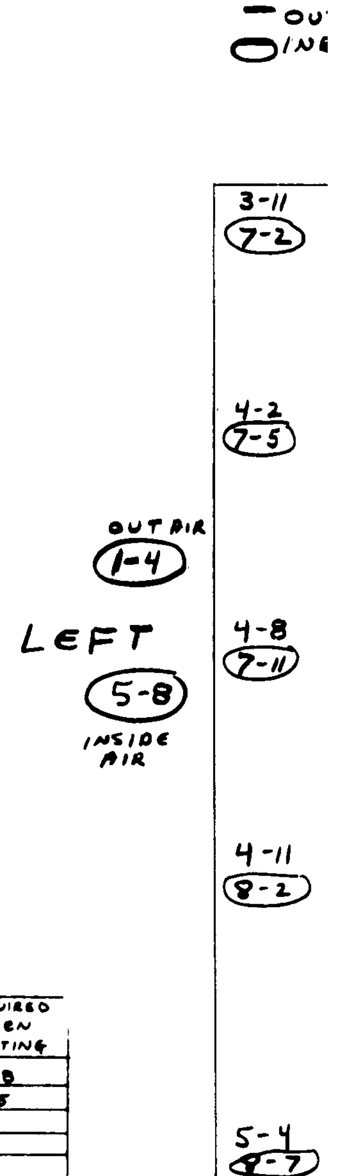


PL
OF

FWD BULKHEAD INB'D 3-2
AFT BULKHEAD INB'D 3-4
TEST STAND SURFACE (RT) 3-5
TEST STAND SURFACE (LT) 3-6

BUREAU OF NAVAL WEAPONS
THERMO-SHIELD CANOPY
TEST PROGRAM

AVG. DESIRED OUTB'D SURFACE TEMP	REQUIRED OVEN SETTING	AVG DESIRED OUTB'D SURFACE TEMP	REQUIRED OVEN SETTING
260°F	310°F	390°F	448
270°	317	400°	455
280°	328	410°	
290°	343		
300°	355		
310°	360		
320°	370		
330°	385		
340°	400°		
350°			
360°	415		
370°	~~430~~ 425		
380°	~~445~~ 438		

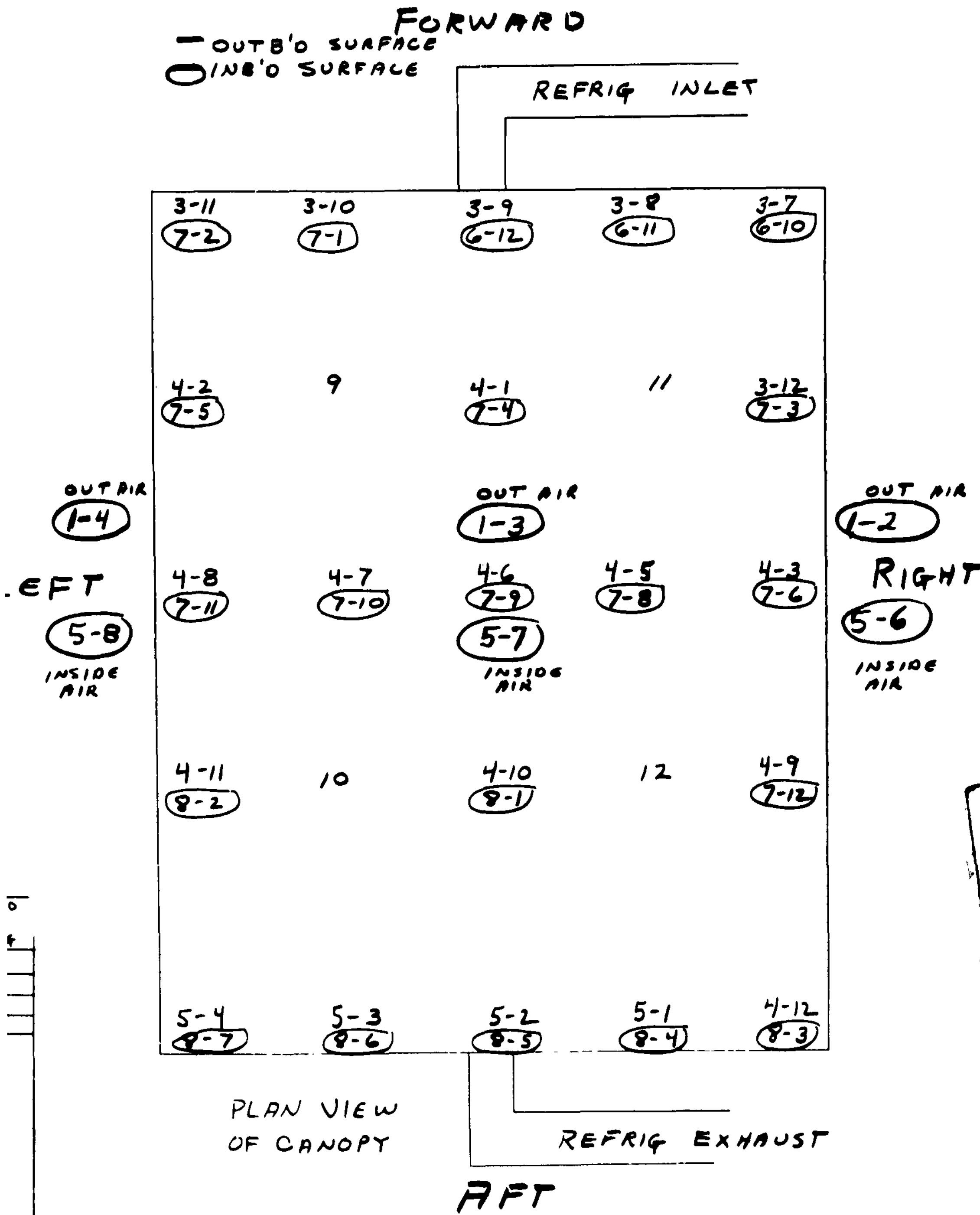


Figure 9 - Schematic Diagram of Thermocouple Code Identification System for Phase III Testing

Pilot runs No. 15 thru 25 were then conducted in one continuous test sequence similar to that which would be performed in Test No. 1 in order to gain temperature soak time characteristics and to thoroughly evaluate the adequacy of the test oven and refrigeration system under actual test conditions.

Followingin Table II, page 33 , is a brief chronological test history for the completion of pilot testing with the No. 5 canopy.

Figure 10 shows the locations of the initial delaminations in the No. 5 canopy and the size to which they had grown at the time testing was terminated.

All thermocouple data collected in pilot testing and Test No. 1 has been tabulated in Tables III thru VII. Verbal descriptions as well as code number identification is included at the top of each column. Each test run, representing 20-25 minutes (after stabilization at a test temperature), is identified in the extreme left hand column of each Table.

General observations based on correlating all test temperatures for the pilot test are itemized below. Various temperatures at each point of delamination are seen in Table VIII. (All interface temperatures have been calculated and are based on inboard and outboard surface temperatures and the resulting temperature gradients established in the laminate by the surface temperatures).

(1) All delaminations were seen to start at the inner face between the outboard as cast Plex 55 face sheet and the F-3 interlayer.

(2) No "shrink back" in the structural face sheet of stretched Plex 55 resulted, even though the stretched Plex 55 inner face temperature in some areas eventually reached 272°F with a corresponding inboard surface temperature of 175°F.

(3) No failure was catastrophic and 8.6 psi pressure was still being maintained in the canopy at the conclusion of testing.

(4) The average outboard surface temperature of the canopy was within ± 12°F of nominal test run temperatures. This temperature spread is larger than the ± 2°F spread which existed in the zone check of the empty test chamber.

However, the air distribution and circulation is adequate even though the installation of the massive canopy test stand and refrigeration ducting in the chamber did slightly disrupt air distribution and circulation.

5. The wide spread in inboard temperatures of the stretched Plex 55 (reference thermocouple code points 6-10 thru 8-7) was due to several hot spots on the interior surface of the canopy caused by inadequate circulation of the refrigeration air.

Time	Start of Run No.	End of Run No.	Test Oven Temp. (boundry layer air)	Outboard Surface Temperature	Remarks
10:37-11:19AM					Oven warmup
11:19	15		300°F	260°F	
11:42		15			
11:50	16		317	270°F	
12:10 PM		16			
12:36	17		328	280°F	
12:58		17			
1:00	18		343	290°F	
1:20		18			
1:23	19		355	300°F	
1:43		19			
1:47	20		360	310°F	
2:10		20			
2:15	21		370	320°F	
2:32		21			
2:40					Est. Start of #1 delam. at top edge of forward hoop
2:43	22		385	330°F	
2:50					Start of #2 &#3 delaminations.
3:05					The #1 delam. was first discovered but had been present for some time
3:09		22			
3:14	23		400	340°F	
3:20					4th Delam. started
3:34		23			
3:38	24		415	350°F	
3:58					Start of #6 delamination
4:12		24			
4:20	25		445	380°F	
4:41		25			Stop test

Table II - Chronological Pilot Test History (No. 5 Canopy)

Figure 10. Test Canopies Showing Delaminations Which Occurred During Testing.

✓ ①

						OUTB'D STRETCHED PLEX AT EDGE ATTACHMENT HOLES BEHIND STEEL RAIL						OUTB'D THERMAL BARRIER BEHIND TONGUE OF ALUMINUM EXTRUSION							OUTB'D STRETCHED PLEX AT EDGE ATTACHMENT HOLES BEHIND ALUMINUM EXTRUSION					
						FWD RT RAIL	MIDDLE RT RAIL	AFT RT RAIL	FWD LT RAIL	MIDDLE LT RAIL	AFT LT RAIL	FWD RT RAIL	MIDDLE RT RAIL	AFT RT RAIL		FWD LT RAIL	MIDDLE LT RAIL	AFT LT RAIL	FWD RT RAIL	MIDDLE RT RAIL	AFT RT RAIL	FWD LT RAIL	MIDDLE LT RAIL	AFT LT RAIL
TEST RUN #	OVEN SETTING	REF 1-1	1-2	1-3	1-4	1-5	1-6	1-7	1-8	1-9	1-10	1-11	1-12	2-1	REF 2-2	2-3	2-4	2-5	2-6	2-7	2-8	2-9	2-10	2-11
NO. 1	150°F	8.6 PSI PRESSURE	53 •	158	65	70	OPEN	70	71	72	72	72	72	72	–	73	73	73	69	74	68	68	62 •	64 •
No 2	150°F	NO PRESSURE	157 •	162	162	70	OPEN	88	89	90	90	90	90	90	–	85 •	90	90	87	85	85	85	88	88
NO. 8	160°F	NO PRESSURE	153 •	164	164	73	OPEN	92	92	93	93	100 •	103 •	102 •	–	106	108	108	98	100	100	98	101	101
NO. 3	300°F	8.6 PSI PRESSURE	293 •	302	302	102	OPEN	102	102	104	105	91 •	94 •	91 •	–	96	102 x	102 x	87	89	89	90	98 x	98 x
No. 4 NO CO_2	300°F	NO PRESSURE	292 •	309	309	111	OPEN	110	110	112	112	98	100	97	–	99	105 x	105 x	91	93	93	93	102 x	102 x
No. 5 NO CO_2	280°F	8.6 PSI PRESSURE	274 •	293	289	72	OPEN	55 •	76	74	61 •	84 •	98	91 •	–	105	110 x	107 x	83 •	92	88	90	104 x	98
No. 6 NO CO_2	280°F	NO PRESSURE	274 •	[illegible]	253	60	OPEN	54 •	64	63	57 •	91 •	102	99 •	–	105	109 x	108 x	86 •	95	92	92	103 x	101 x
No. 7 CO_2	280°F	NO PRESSURE	275 •	286	289	104 •	OPEN	100 •	111	116	111	110	111	112	–	112	117 x	122 x	105	106	109	105	112 x	119 x
No. 9 CO_2	280°F	NO PRESSURE	265 •	280	280	98	OPEN	90 •	99	104	102	127	128	125	–	128	135 x	137 x	117	117	117	115	126 x	128 x
No 10 CO_2	350°F	NO PRESSURE	336 •	351	354	56 •	OPEN	53 •	66	66	61	92 •	114	98 •	–	110	120 x	118 x	88 •	109	96	95	111 x	110 x
No. 11 CO_2	280°F	NO PRESSURE	272	279 x	279	110 •	OPEN	111 •	115	116	116	126 •	132 •	139 •	–	141	143	142	121	124	124	124	133 x	133
No 12 CO_2	280°F	NO PRESSURE	269	281 x	279	93 •	OPEN	85 •	98	102	98	132 •	137 •	134 •	–	144	146	146	125	127	127	127	138 x	136
No 13 NO CO_2	280°F	NO PRESSURE	271	280 x	275	126	OPEN	126	127	128	130	136 •	139 •	139 •	–	148	157	157	132	132	132	132	144 x	144
No 14 CO_2	355°F	NO PRESSURE	344	351	340	84	OPEN	71	84	89	83	161	161	155	–	168	176	170	143	145	145	142	163	155
5 CO_2	300-260	PRESSURED	[illegible]69	293 x	279	86		82	74	94	93	114	124	114	–	142	149	147	109	115	108	120	140 x	136 x
[illegible] O_2	317-270	"	3[illegible]	316 x	303	86	"	78	91	91	91	114	124	110	–	146	154	154	108	115	104	120	144 x	143
[illegible] NO CO_2	328-280	"	3[illegible]	324 x	313	91	"	82	85	93	93	108	110	108	–	143	155	152	108	108	104	108	145 x	148
8 NO CO_2	343-290	"	331	337 x	331	08	"	88	91	95	97	115	116	116	–	152	165	165	120	118	114	116	156	153
19 CO_2	355-300	"	341	348 x	338	123	"	103	115	115	120	138	140	140	–	163	175	175	135	134	133	140	165	165
20	360-310	"	346	353 x	346	68	"	34	39	53	55	65	72	81	–	86?	110?	173	121	121	119	124	162	162
21	370-320	"	354	365 x	344	51	"	38	44	50	51	58	68	66	–	60	68	71	98	98	98	98	102	110
22 CO_2	385-330	"	363	374 x	365	72	"	33	38	61	62	74	99	104	–	100	108	127	104	104	104	104	108	114
23 CO_2	400-340	"	382	394 x	375	68		57	78	78	68	124	145	123	–	162	188	179	112	129	112	128	170	162
24 CO_2	415-360	"	394	405 x	389	28	"	60	77	78	68	125	143	118	–	159	186	177	111	128	108	123	169	150
25 NO CO_2	445-380	"	[illegible]8	433 x	415	74		63	84	84	72	134	161	134	–	165	208	187	120	143	121	138	170	170
No 26 (S) START (F) FINISH 10°F Avg. NO CO_2	310-260	8.6 PSI PRESSURE	311 / 3	320 / 319	290 / 286	118	120	117	116	123	124	129	147	120	–	130	143	151	116	140	116	112	132	137
No. 27 (S) (F) Avg.	320-270		3[illegible] / 3.5	3[illegible]4 / 320	279 / 296	99	101	91	99	102	98	136	160	118	–	140	157	162	120	150	115	118	143	146
28 (S) (F) Avg	330-280		323 / 324	330 / 329	30[illegible] / 292	3	15	110	12	116	116	139	165	124	–	195	164	167	122	154	120	122	149	150
29 (S) (F) Avg	345-290		34[illegible] / 337	332 / 342	299 / 314	117	125	108	118	125	20	148	176	182	–	155	174	177	132	165	129	130	158	160
30 (S) (F) Avg	355-300		341 / 344	346 / 353	318 / 328	96	107	102	106	108	108	147	183	126	–	155	178	178	127	170	123	128	160	160

SE

22 CO₂	385-330		[illegible]	[illegible]	[illegible]																			
23	400 390	-	32	344	375	68		57	78	78	68	124	45	23	-	62	188	179	112	129	112	128	170	162
24 CO₂	415 380		[illegible]	415	389	58		50	77	78	68	125	143	118	-	159	186	177	111	128	108	123	169	150
25 CO₂	415-380			433	415	74		3	84	84	72	134	161	154	-	165	208	187	120	143	121	138	170	170
No 26 (S) START (F) FINISH 10°F Avg. No CO₂	310 260	BLAST REMOVED	311 / 3	320 / 39	290 / 286	118	120	117	116	123	124	129	147	120	-	130	143	151	116	140	116	112	132	137
No 27 (S) (F) Avg.	320 270	-	3 / 35	3 / 320	279 / 296	77	101	91	99	102	98	136	160	118	-	140	157	162	120	150	115	118	143	146
28 (S) (F) Avg.	330 280	-	323 / [illegible]	330 / 327	30 / 292	3	15	10	2	116	116	139	165	124	-	175	164	167	122	154	120	122	148	150
29 (S) (F) Avg.	345-290		3 / 337	332 / 342	299 / 314	117	125	108	118	125	20	148	176	182	-	155	174	177	132	165	129	130	158	160
30 (S) (F) Avg.	355 300	-	341 / 344	346 / 353	318 / 328	96	107	102	106	108	108	147	183	126	-	155	178	178	127	170	123	128	160	160
31 (S) (F) Avg.	360 310	"	352 / 350	361 / 357	316 / 337	9	124	114	120	124	124	156	190	136	-	162	184	184	136	178	132	135	166	167
32 (S) (F) Avg.	370 322		350 / 354	5 / 364	397 / 322	100	101	93	101	101	101	154	194	127	-	150	185	185	131	180	124	132	166	166
33 (S) (F) Avg.	385 330		390 / 373	401 / 382	363 / 333	121	125	7	120	124	126	161	200	138	-	167	190	191	139	186	134	138	171	171
34 (S) (F) Avg.	398 340		392 / 375	396 / 391	360 / 351	96	95	86	98	98	94	163	206	131	-	168	195	195	137	200	128	138	174	172
35 (S) (F) Avg.	407 350 / 405 350		408 / 76	4 8 / 399	84 / 366	120	22	6	119	122	123	170	212	142	-	173	200	200	149	196	188	142	179	178
36 (S) (F) Avg.	417 360		403 / 400	4 / 406	381 / 387	100	100	86	104	104	94	174	218	140	-	176	206	206	146	202	138	145	185	184
37 (S) (F) Avg.	430-370 / 435-370	" / "	4 9 / 0	437 / 414	402 / 397	122	127	119	123	126	127	180	224	150	-	181	212	212	152	207	146	149	189	188
No 38 (S) (F) Avg.	5 380 / 418 380		424 / 419	434 / 428	396 / 374	94	98	80	78	98	84	179	230	144	-	181	215	214	192	211	140	147	191	188
No 39 (S) (F) Avg.	448-390	-	4 / 432	424 / 441	388 / 378	91	88	80	94	94	85	176	232	140	-	182	212	211	144	210	136	146	186	184
No 40 (S) (F) 10°F Avg. No CO₂	455-400	BLAST REMOVED	446 / 439	454 / 444	400 / 400	128	132	124	128	132	133	185	238	156	-	190	220	220	156	218	150	154	194	194

Table III - Thermocouple Data - Pilot Testing and Test No. 1 - Sheet 1

②

	2-12 FWD TOP CENTER LINE UNDER ALUMINUM STRAP	3-1 AFT TOP CENTER LINE UNDER ALUMINUM ANGLE	3-2 FWD MID BULKHEAD	3-3 REF	3-4 AFT MID BULKHEAD	3-5 TEST STAND SURFACE RT	3-6 TEST STAND SURFACE LT	3-7 OUTSIDE ① FWD HOOP RT LOWER CORNER	3-8 OUTSIDE ② FWD HOOP 45° RT	3-9 OUTSIDE ③ FWD HOOP TOP CENTER LINE	3-10 OUTSIDE ④ FWD HOOP 45° LT	3-11 OUTSIDE ⑤ FWD HOOP LT LOWER CORNER	3-12 OUTSIDE ⑥ FWD MID HOOP RT LOWER RAIL	4-1 OUTSIDE ⑦ FWD MID HOOP TOP CENTER LINE	4-2 OUTSIDE ⑧ FWD MID HOOP LT LOWER RAIL	4-3 OUTSIDE ⑨ MID HOOP RT LOWER RAIL	4-4 REF	4-5 OUTSIDE ⑩ MID HOOP 45° RT	4-6 OUTSIDE ⑪ MID HOOP TOP CENTER LINE	4-7 OUTSIDE ⑫ MID HOOP 45° LT	4-8 OUTSIDE ⑬ MID HOOP LT LOWER RAIL	4-9 OUTSIDE ⑭ AFT MID HOOP RT LOWER RAIL	4-10 OUTSIDE ⑮ AFT MID HOOP TOP CENTER LINE	4-11 OUTSIDE ⑯ AFT MID HOOP LT LOWER RAIL	4-12 OUTSIDE ⑰ AFT HOOP RT LOWER CORNER
No 1	62	6	5	-	70	67	70	111•	134	131	131	134	136	134	134	130	-	135	137	137	136	128	135	142	115•
No 2	87	86	86	-	85	87	72	131•	140	140	140	137	139	144	142	142	-	145	146	146	142	140	145	146	137
No 8	96	76	78	-	82	94	98	137•	142	139•	141	146	138•	141	138•	136•	-	-	148	148	147	141	146	150x	139•
No 3	93	90•	80	-	91	108	113	205•	242x	227	223	212•	229	238	239	230	-	252	252	249x	232	230	243x	248x	211•
No 4	95	88	81	-	93•	116	117	214•	247x	234	230	221•	234	245x	235	236	-	259x	259x	256x	238	236	251x	254x	229
No 5	98	82•	80	-	79	67	76	202•	235	225	225	212•	222	236	228	228	-	250x	251x	248x	224	228	245x	245x	219•
No 6	101	11	82	-	74•	64	71	206•	235	225	225	214•	222	238	230	230	-	251x	251x	250x	228	228	248x	248x	224
No 7	74	92	73	-	87x	106	108	210•	228	224	229	215•	221	232	223	223	-	OPEN	245x	243x	232	231	242x	245x	222
No 9	113	112	80	-	82	100•	111	228	236	229	231	235	225	231	220•	220•	-	OPEN	239	240	238	232	241x	246x	224
No 10	98	92•	58•	-	49	53•	82	256•	284	278	278	261•	273	288	274	276	-	294x	301x	301x	286	283	300x	301x	271
No 11	116	118	86	-	91	118•	127	228•	234	234	234	244	232	232	234	231	-	OPEN	240	242	242	232	248	248x	230
No 12	119	120	77	-	74	96•	105	232•	236	236	236	244	234	235	236	234	-	OPEN	245	246	246	235	249x	250x	231
No 13	124	124	97	-	100	132•	142	238	241	242	245	250x	236	236	237	234	-	OPEN	247	247	247	239	248	254x	236
No 14	155	147	109	-	72	80	104	300	312	310	310	310	292	295	296	291	-	OPEN	308	310	306	298	311	314	294
No 15	136•	93	94•	-	[illegible]	97	109	253	270x	271x	266x	266x	250	256	257	248	-	"	264x	264x	258	255	266x	269x	248
16	145•	80	90•	-	58	100	113	267	285x	287x	279x	276x	260	268	268	267	-	"	278x	277	270	265	278x	280x	259
17	144•	94	96•	-	48	104	109	257	290x	296x	288x	281x	266	278	274	258	-	"	290x	287x	276	273	291x	290x	263
18	152•	100	100•	-	63	96	116	283	304x	307x	300x	296x	279	289	289	277	-	"	300x	300x	290	288	302x	303x	279
19	160•	59	58•	-	38	138	150	294	314x	318x	312x	308x	292	300	304	290	-	"	309x	309x	302	300	311x	314x	291
20	165•	90	89•	-	49	50	55	298	320x	325x	321x	314x	294	303	303	291	-	"	310x	312x	303	301	313x	316x	295
21	162•	86	82•	-	38	50	55	307	331x	F#1 335x	F#2 326x	316x	301	314	311	300	-	"	321x	321x	310	308	325x	325x	301
22	120	105	104•	-	30	61	70	314	F#3 340x	345x	340x	331x	316	324	324	316	-	"	334x	334x	326	325	338x	338x	317
23	75•	72	72•	-	45	82	102	331	358x	366x	F#4 350x	339x	324	337x	334	320	-	"	348x	348x	332	332	354x F#5	350x	323
24	68•	100	[illegible]•	-	46	81	103	343	370x	382x	361x	347	333	357x	344	OPEN	-	"	361x	357x	342	338	366x	359x	327
25	85•	06	[illegible]•	-	53	96	108	371	400x F	411x F	394x F	374	366	400x	376	OPEN	-	"	400x F	395x F	378	372	408x F	389x	362
26 (S)								263	276	264	254	255	255	260	260	252	-	-	259	266	266	250	263	272	232
(F)	114	121	92	-	98	141	150	260	272	262	254	266	256	262	262	254	-	OPEN	263	268	268	254	264	272	238
27 (S)								261	274	267	259	273	263	267	270	261	-	-	270	274	278	261	271	280	246
(F)	123	134	86	-	92	17	124	268	281	273	265	276	269	274	276	267	-	OPEN	275	281	293	266	277	284	246
28 (S)								275	288	280	272	278	275	280	282	272	-	-	282	268	290	272	283	290	254
(F)	127	138	87	-	99	136	144	280	289	292	275	286	278	283	285	276	-	OPEN	285	291	294	276	285	293	257
29 (S)								286	296	289	281	294	286	296	293	284	-	-	292	300	301	284	293	301	267
(F)	132	49	93	-	106	134	142	292	300	294	287	302	290	296	298	290	-	OPEN	297	304	306	290	298	306	270
30 (S)								296	306	300	292	303	296	301	303	295	-	-	302	309	310	294	303	310	275
(F)	137	148	94	-	96	129	137	302	312	306	298	308	304	306	307	300	-	OPEN	308	315	317	300	308	316	277
31 (S)								308	316	310	301	316	306	311	314	305	-	-	312	319	320	304	312	321	282
(F)	40	151	97	-	57	70	148	310	316	310	304	318	306	314	315	307	-	OPEN	316	320	320	306	313	324	278
32 (S)								316	323	318	300	327	313	318	323	312	-	-	320	328	328	312	321	329	289
(F)	142	55	98	-	75	122	131	319	323	318	310	323	313	319	324	312	-	OPEN	321	328	328	312	321	329	283

[illegible]	75*	72	92*	-	45	82	102	331	358*	365*	350*	339*	324	337*	334	320	-	"	348x	348x	372	332	352x	350x	323
[illegible]	68*	00	•*		40	81	103	343	370*	382*	361*	347	333	357*	344	OPEN	-	"	361x	357x	342	338	366x	359x	327
25	75*	76	[illegible]	-	53	96	108	371	400*	411*	394*	374	366	400*	376	OPEN	-	"	400x	395x	378	372	408x	389x	362
									F	F	F								F	F			F		
26 (S)								263	276	264	254	255	255	260	260	252	-	-	259	266	266	250	263	272	232
(F)	114	121	92	-	98	141	150	260	272	262	254	266	256	262	262	254	-	OPEN	263	268	268	254	264	272	238
27 (S)								261	274	267	259	273	263	267	270	261	-	-	270	274	278	261	271	280	246
(F)	123	134	86	-	72	17	124	268	281	273	265	276	269	274	276	267	-	OPEN	275	281	293	266	277	284	246
28 (S)								275	288	280	272	278	275	280	282	272	-	-	282	268	290	272	283	290	254
(F)	127	138	87	-	[illegible]	136	144	280	289	282	275	286	278	283	285	276	-	OPEN	285	291	294	276	285	293	257
29 (S)								286	296	289	281	294	286	290	297	284	-	-	292	300	301	284	293	301	267
(F)	132	149	93	-	106	139	142	292	300	294	287	302	290	296	298	290	-	OPEN	297	304	306	290	298	306	270
30 (S)								[illegible]	306	300	292	303	296	301	308	295	-	-	302	309	310	294	303	310	275
(F)	37	148	74		76	29	137	302	312	306	298	308	302	306	307	300	-	OPEN	308	315	317	300	308	316	277
31 (S)								308	316	310	301	316	306	311	314	305	-	-	312	319	320	304	312	321	282
(F)	140	151	97	-	107	140	148	310	316	310	304	318	306	314	315	307	-	OPEN	316	320	320	306	318	324	278
32 (S)								316	323	318	300	327	313	318	323	312	-	-	320	328	328	312	321	329	287
(F)	142	155	98	-	75	122	131	319	323	318	310	323	313	319	324	312	-	OPEN	321	328	328	312	321	329	283
33 (S)								330	336	330	320	329	325	330	333	323	-	-	330	338	338	322	329	337	297
(F)	146	158	160	-	107	148	158	335	338	332	322	336	328	338	338	326	-	OPEN	334	343	343	326	334	342	298
34 (S)								343	348	341	331	340	336	341	344	333	-	-	341	349	349	334	340	347	307
(F)	150	162	102	-	97	116	120	341	350	343	334	346	350	344	344	336	-	OPEN	340	354	354	338	345	353	308
35 (S)								356	361	351	342	354	348	353	358	345	-	361	351	360	360	346	352	360	317
(F)	152	165	104	-	106	148	158	350	355	350	344	359	347	352	356	348	-	OPEN	354	361	361	346	354	360	318
36 (S)								360	365	358	348	360	355	359	364	351	-	OPEN	360	369	368	353	360	368	331
(F)	156	170	107	-	104	115	133	358	365	360	352	360	356	361	366	354	-	OPEN	362	371	370	355	362	367	326
37 (S)								382	389	376	364	376	372	376	384	368	-	381	376	383	383	368	374	382	344
(F)	[illegible]	174	110	-	110	150	162	371	376	372	363	372	368	373	377	366	-	380	376	382	382	368	374	380	343
38 (S)								386	388	383	373	382	379	383	388	76	-	394	385	394	394	377	383	390	367
(F)	165	178	112	-	101	101	127	376	385	381	372	382	379	383	388	375	-	394	386	393	390	378	394	391	352
39 (S)							-	390	393	388	377	382	382	390	393	381	-	402	395	400	400	384	390	398	361
(F)	167	180	111	-	96	108	131	387	397	390	382	392	388	394	397	385	-	403	396	404	403	388	394	401	359
40 (S)							-	370	379	393	384	386	388	394	399	388	-	406	399	405	404	390	396	401	363
(F) Avg.	168	181	114	-	115	162	174	397	402	397	388	392	392	398	403	391	-	402	400	407	407	392	398	406	368

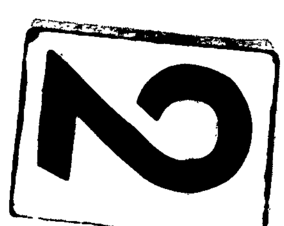


Table IV - Thermocouple Data - Pilot Testing and Test No. 1 - Sheet 2

③

INS'D STRETCHED PLEX AT EDGE ATTACHMENT HOLES BEHIND STEEL (5-9 to 5-11); INS'D ANGLE (5-12 to 6-2); INS'D STRETCHED PLEX BEHIND ORLON LAMINATE (6-3 to 6-9)

	Aft Hoop 45° RT (18) Outside	Aft Hoop Top Center Line (19) Outside	Aft Hoop 45° LT (20) Outside	Aft Hoop Lt Lower Corner (21) Outside	REF	Mid Hoop Rt Rail Inside Air	Mid Hoop Top Center Line Inside Air	Mid Hoop Lt Rail Inside Air	Fwd Rt Rail	Middle Rt Rail	Aft Rt Rail	Fwd Lt Rail	Middle Lt Rail	Aft Lt Rail	Fwd Rt Rail	Middle Rt Rail	Aft Rt Rail	REF	Fwd Lt Rail	Middle Lt Rail	Aft Lt Rail	Fwd Hoop Rt Lower Corner (2) Inside	Fwd Hoop 45° RT (3) Inside	Fwd Hoop Top Center Line (1) Inside	Fwd Hoop 45° LT (4) Inside
	5-1	5-2	5-3	5-4	5-5	5-6	5-7	5-8	5-9	5-10	5-11	5-12	6-1	6-2	6-3	6-4	6-5	6-6	6-7	6-8	6-9	6-10	6-11	6-12	7-1
No 1	126	99 •	128	135	-	74	78	80	77	72	72	74	72	72	72	72	70	-	72	74	74	74 •	94	94	94
No 2	138	132 •	138	142	-	70	71	71	89	90	90	90	90	90	89	91	90	-	88	89	89	97	93	93	93
No. 8	142 x	142	149	153 x	-	56	52	52	88	90	90	90	90	91	86	87	89	-	86	89 x	92 x	87	71 •	73 •	74 •
No 3	227 •	194 •	219	227	-	64	63	62	97	97	98	98	98	101	87	84	84	-	88 x	88 x	90 x	102 •	93 •	93 •	98 •
No 4	232	214	236	235	-	63	62	61	107	108	110	107	109	112	96	86	96	-	88	90 x	94 x	111	100 •	100 •	102 •
No. 5	228 •	189 •	208	228	-	58	57	57	68	65	60 •	72	71	62 •	77 •	82	82	-	87	89 x	93 x	104 •	92 •	92 •	98 •
No 6	229	212 •	232	232	-	55	55	51	59	59	57	63	62	58	73 •	82	82	-	87	89 x	89 x	108 •	98 •	98 •	98 •
No 7	226	212 •	231	230	-	53	52	52	103	106	104	105	108	103	88	90	96 x	-	87	91	104 x	104 •	81 •	89 •	96 •
No 9	228	223	245 x	250 x	-	40	40	40	89	92	89	93	95	94	88	92	94	-	90	96 x	105 x	103 •	73 •	86 •	88 •
No 10	278	244 •	284	278	-	0	0	0	48	48	49	56	56	56	56 •	70	70	-	67	76 x	82 x	81 •	46 •	70 •	77 •
No. 11	236	236	248	254 x	-	74	70	64	109	109	109	112	112	112	103 •	103 •	102 •	-	108	109	109	112 •	86 •	100 •	86 •
No 12	240	240	249	252 x	-	45	46	46	90	91	84	94	95	90	97 •	100 •	98 •	-	109	107	108	102 •	77 •	88 •	89 •
No 13	239	240	250 x	255 x	-	Below 72	Below 58 •	Below 64	124	124	124	124	125	124	112	110	110	-	114	116	116	134	131	121	142
No. 14	297	300	311	316	-	44	44	46	76	75	71	80	81	77	110	108	110	-	122	124	120	136	150	130	156
15	244	206 •	256	269 x	-	35	38	39	82	74	74	86	82	83	85	81	81	-	98	98	104	115	139 x	161 x	139 x
16	249	214 •	266	280 x	-	?	115?	0?	75	65	65	78	68	76	72	66	62	-	92	88	98	99 •	130	176 x	133
17	256	230 •	274	287 x	-	35	39	39	84	79	79	82	80	81	81	76	74	-	96	96	101	103	111	162 x	145 x
18	270	241 •	288	302 x	-	53	52	52	78	78	79	83	84	85	85	80	77	-	85	90	95	116	121	172 x	156 x
19	285	252 •	300	314 x	-	26	35	43	96	98	99	100	103	105	104	96	96	-	86	95	101	139	151 x	187 x	168 x
20	286	245 •	299	312 x	-	8	18	18	36	42	42	46	50	50	50	59	59	-	63	68	70	71 •	81	186 x F#1	151 x F#2
21	300	252 •	310	321 x	-	34	35	36	38	39	38	41	44	43	47	54	56	-	50	55	57	58 •	62 • F#3	186 x	153 x
22	314	274 •	325	332 x	-	49	52	52	67	65	64	67	70	70	87	88	88	-	110	113	116	137	166 x	200 x	170 x F#4
23	328	264 •	334	346 x	-	0	0	0	58	42	44	62	51	52	63	58	57	-	89	90	104	105	139 x	198 x	147 x
24	338	271 •	348	354 x	-	4	180	9	61	50	51	68	62	60	70	74	62	-	90	109	108	133	156	210 x	173 x
25	372	303 •	378	382 x	-	28	59	34	68	58	58	74	70	65	93	86	79	-	104	121	127	155	170 F	213 x F	176 x F
26 (S)	250	250	274	278	-	73	66	74														80	84	82	82
(F)	250	252	272	278	-	78	70	77	101	112	108	96	110	110	90	106	97	-	90	106	104	84	86	85	86
27 (S)	256	250	281	288	-	80	73	80														87	90	88	88
(F)	261	264	283	288	-	80	74	78	88	94	89	88	94	92	94	111	98	-	99	114	108	87	96	88	89
28 (S)	267	270	289	293	-	81	74	80														88	91	90	91
(F)	270	273	290	295	-	82	76	82	99	107	103	96	104	104	96	114	101	-	96	117	112	90	92	92	92
29 (S)	277	280	299	306	-	85	78	85														91	95	94	94
(F)	282	285	304	310	-	86	80	85	103	114	101	101	112	107	102	122	109	-	103	125	120	94	97	96	96
30 (S)	287	290	308	314	-	86	79	85														94	97	97	97
(F)	292	296	313	320	-	85	80	85	95	100	98	93	100	100	100	120	104	-	101	124	117	94	96	96	97
31 (S)	295	298	315	323	-	87	80	87														96	98	98	97
(F)	298	301	315	324	-	91	84	90	106	115	108	104	113	112	106	129	110	-	107	131	124	98	101	101	101
32 (S)	304	306	320	330	-	90	83	89														98	101	100	101
(F)	304	306	320	331	-	86	81	86	91	94	92	91	96	91	[illegible]	[illegible]	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]			

1

SECTI

23		328	264•	339	346x	-	5	6	0	58	42	44	62	51	52	63	58	57	-	84	90	104	103	137	178x	177
24		338	271•	348	354x	-	4	80	9	5	50	51	68	62	60	70	74	62	-	90	104	108	133	156	210x	173x
25		373	303•	18	382x	-	22	59	34	68	58	58	74	70	65	83	86	79	-	104	121	127	155	170 F	213x F	176x F
26	(S)	250	250	274	278	-	73	66	74														80	84	82	82
	(F)	250	252	272	278	-	78	70	77	101	112	108	96	110	110	90	106	97	-	90	106	104	84	86	85	86
27	(S)	256	250	281	288	-	80	73	80														87	90	88	87
	(F)	261	264	283	288	-	80	74	78	88	94	89	88	94	92	94	111	98	-	94	114	108	87	90	88	89
28	(S)	267	270	289	293	-	81	74	80														88	91	90	91
	(F)	270	273	290	295	-	82	76	82	99	107	103	96	104	104	96	114	101	-	96	117	112	90	92	92	92
29	(S)	277	280	299	306	-	85	78	85														91	95	94	94
	(F)	282	285	304	310	-	86	80	85	103	114	101	101	112	107	102	122	109	-	103	125	120	94	97	96	96
30	(S)	287	290	308	314	-	86	79	85														94	97	97	97
	(F)	292	296	313	320	-	85	80	85	95	100	98	93	100	100	100	120	104	-	101	124	117	94	96	96	97
31	(S)	293	298	315	323	-	87	80	87														96	98	98	99
	(F)	298	301	315	324	-	91	84	90	106	115	108	104	113	112	106	129	110	-	107	131	124	98	101	101	101
32	(S)	304	306	320	330	-	90	83	89														98	101	100	101
	(F)	304	306	320	331	-	86	81	86	91	94	92	91	96	96	102	126	105	-	104	129	120	96	100	100	100
33	(S)	313	315	328	334	-	89	82	88														98	101	101	101
	(F)	318	319	332	342	-	72	85	90	106	115	112	104	113	114	108	132	111	-	108	133	126	101	104	104	104
34	(S)	324	327	339	345	-	92	86	93														102	105	104	105
	(F)	328	332	344	354	-	91	86	90	90	90	88	90	94	92	106	130	109	-	108	134	123	101	104	104	105
35	(S)	335	338	350	357	-	73	86	91														103	106	106	106
	(F)	336	338	351	360	-	90	83	94	107	114	111	105	112	112	111	136	115	-	112	137	127	105	108	108	110
36	(S)	342	345	358	362	-	94	86	98														108	111	111	113
	(F)	345	348	361	370	-	96	90	94	94	94	90	94	100	94	114	138	116	-	115	143	132	106	109	110	111
37	(S)	356	360	374	384	-	98	90	96														108	111	111	112
	(F)	356	360	372	380	-	99	92	99	109	117	114	109	117	117	117	144	121	-	127	145	136	110	113	113	114
38	(S)	367	370	383	375	-	101	94	102														114	118	118	120
	(F)	367	371	382	390	-	98	92	97	92	86	84	92	96	86	116	140	118	-	117	146	134	110	113	113	115
39	(S)	373	376	389	397	-	99	92	96														110	112	113	114
	(F)	376 FAILURE	380	392	400	-	97	92	95	90	86	84	89	93	87	112	138	113	-	113	141	129	109	112	112	114
40	(S)	388	384	392	400	-	94	88	98														110	114	114	116
	(F) Avg	394	388	396	404	-	104	96	102	114	122	120	113	122	124	119	148	123	-	120	149	141	114	118	118	119

Table V - Thermocouple Data - Pilot Testing and Test No. 1- Sheet 3

1

4

	FWD HOOP LT LOWER RAIL (5) INSIDE 7-2	FWD MID HOOP RT LOWER RAIL (6) INSIDE 7-3	FWD MID HOOP TOP CENTER LINE (7) INSIDE 7-4	FWD MID HOOP LT LOWER RAIL (8) INSIDE 7-5	MID HOOP RT LOWER RAIL (3) INSIDE 7-6	REF 7-7	MID HOOP 45° RT (9) INSIDE 7-8	MID HOOP TOP CENTER LINE (10) INSIDE 7-9	MID HOOP 45° LT (11) INSIDE 7-10	MID HOOP LT LOWER RAIL (13) INSIDE 7-11	AFT MID HOOP RT LOWER RAIL (14) INSIDE 7-12	AFT MID HOOP TOP CENTER LINE (15) INSIDE 8-1	AFT MID HOOP LT LOWER RAIL (16) INSIDE 8-2	AFT HOOP RT LOWER CORNER (17) INSIDE 8-3	AFT HOOP 45° RT (18) INSIDE 8-4	AFT HOOP TOP CENTER LINE (19) INSIDE 8-5	AFT HOOP 45° LT (20) INSIDE 8-6	AFT HOOP LT LOWER CORNER (21) INSIDE 8-7	REF 8-8	FWD HOOP ING'D STRETCHED PLEX 45° RT INSIDE 8-9	FWD HOOP ING'D STRETCHED PLEX 45° LT INSIDE 8-10	AFT HOOP ING'D STRETCHED PLEX 45° RT INSIDE 8-11	AFT HOOP ING'D STRETCHED PLEX 45° LT INSIDE 8-12	EDGE OF MANHOLE ON BOTTOM 1	CENTER OF MANHOLE ON BOTTOM 2
NO	95	95	95	96	97	-	96	98	98	98	98	98	101x	95	94	95	97	98	-	73	77	77	77	-	-
No 2	95	95	96	96	99	-	103	104	104	104	105	106	107x	105	105	104	106x	106x	-	84	86	86	86	-	-
No 8	92	74•	74•	78	92	-	87	88	86	88	92	92	95	94	93	93	99x	98x	-	77	77	77	82	75	87
No 3	111•	119•	97•	1?•	108	-	127	114	107	110	118x	118x	131x	118x	119x	113	118x	118x	-	80	82	83	83	-	-
No 4	108•	107•	106•	107•	115•	-	126	126	120	122	132x	132x	134x	128x	128x	120	128x	128x	-	86	86	86	86	-	-
No 5	102•	100•	99•	99•	110•	-	118	125	115	115	124	130x	130x	124	126x	119	125x	122	-	80	81	81	82	-	-
No 6	105•	102•	102•	103•	113•	-	126	127	122	122	130	137x	137x	127	128	122	129	127	-	86	86	85	85	-	-
No 7	98•	93•	93•	98•	105•	-	106•	116	110	112	122	126x	128x	122	122	116	127x	126x	-	74	79	80•	87	-	-
No 9	98•	83•	85•	95•	100•	-	104•	115	105•	111	119	122	125	121	120	118	133x	130x	-	71•	75•	81•	93	70	69
No 10	80•	57•	73•	80•	90•	-	96•	109	99•	100•	112	133x	125	112	114	102•	125	114	-	40•	56•	56•	67	-	-
No 11	131	121	96•	140x	133	-	120	122	127	134	131	148x	132	132	135	135	142x	140x	-	90	90	104	104	-	-
No 12	107•	107•	82•	128	124	-	107•	125	123	129	118	145	121	121	121	122	130	125	-	68•	74•	97	97	-	-
No 13	142x	117	91•	129	115•	-	112•	119	119	129	135	132	140x	138	124	125	133	140x	-	128	118	112•	110•	-	-
No 14	150	116	88	132	115	-	120	126	123	132	142	142	148	146	127	132	142	147	-	137	133	129	127	-	-
																								MANHOLE	WINDOW
15	[illegible]	76•	90•	[illegible]	84	-	100	107	100	100	116	118	122	120	116	116	126	126	-	111	103	87	89	67	317
16	108	72•	144x	76•	62•	-	115	154x	116	24•	99•	150x	107	105	108	122	123	108	-	106	100	78	80	49	329
17	125	76•	88•	92	84•	-	106	109	104	102	110	138x	131	123	108	109	130	130	-	114	113	93	93	53	340
18	140x	95	94•	98•	90•	-	96•	98•	104	104	114	117	121	121	113	114	118	122	-	112	113	98	95	63	353
19	12x	94•	108	110•	103•	-	10•	95•	100•	105•	140	141	149x	146x	128	128	150x	150x	-	115	115	107	107	77	352
20	30	58•	67•	68•	58•	-	52•	62•	70•	70•	72•	77	81	80	82	81	86	90	-	72	74	76	76	57	368
21	137x	97	82	90	82	-	48•	55•	54•	54•	58•	57•	71	100	106	110	114	115	-	58	58	58	58	45	380
22	154	119•	116•	140	105•	-	30	136	129	123	148	154	154	150	135	139	158	155	-	135	128	109	109	54	394
23	19	73•	66•	103	56•	-	92•	114	90•	79•	107	FOS 138x	112	112	110	131	136x	113	-	109	102	76	84	34	406
24	112	57•	192x	30	77•	-	154	201x	151	128	137	200x	147	137	150	160	165	141	-	150	142	98	98	21	419
25	157	120•	13.	145	118•	-	149	76x	141	132	153	201x	157	151	160	172	175	154	-	140	137	113	110	25	440
								F	F			F													
																								TOP INSIDE WINDOW	TOP OUTSIDE WINDOW
26 (S)	82	92	94	102	100	-	100	113	95	106	76	114	96	95	104	104	110	104	-	78	74	98	96	274	105
(F) Avg	88	15	100	108	108	-	105	120	102	113	103	120	101	100	108	109	115	108	-	80	77	104	100	269	114
27 (S)	90	102	104	112	112	-	110	125	106	118	108	124	105	104	112	113	119	113	-	82	80	108	104	281	115
(F) Avg	90	104	107	[illegible]	114	-	111	129	108	121	108	127	104	103	113	114	120	112	-	83	81	111	106	280	116
28 (S)	92	104	108	118	116	-	13	131	110	122	110	130	106	105	115	116	121	114	-	84	82	113	108	290	117
(F) Avg	93	107	110	120	118	-	116	132	3	125	113	132	109	107	118	118	124	116	-	86	84	115	100	288	119
29 (S)	75	109	112	122	120	-	7	134	115	128	114	133	110	109	119	120	126	119	-	86	84	117	112	300	119
(F) Avg	77	112	5	124	23	-	120	138	118	131	118	136	114	112	122	124	129	122	-	90	87	120	115	300	120
30 (S)	98	2	16	125	125	-	24	142	120	132	118	138	114	112	122	124	129	121	-	88	85	120	115	313	122
(F) Avg	98	112	116	2.	124	-	21	140	120	131	118	138	114	112	123	125	130	122	-	90	88	121	115	312	124
31 (S)	100	114	9	27	127	-	25	143	122	34	121	140	116	115	126	128	132	125	-	91	89	123	118	314	122
(F) Avg	102	7	20	30	130	-	28	147	124	37	123	144	118	118	128	131	134	127	-	94	91	126	120	318	125
32 (S)	102	7	21	32	31	-	130	149	27	139	124	144	120	118	130	131	137	128	-	94	91	127	121	328	126
(F) Avg	101	[illegible]	21	132	130	-	126	145	25	137	122	144	118	116	128	128	134	126	-	92	90	125	119	326	128
33 (S)	102	8	122	133	131	-	128	48	126	138	124	146	118	117	130	131	135	127	-	93	91	126	121	344	129
(F)	105	22	126	135	135	-	131	152	130	142	127	149	122	121	133	135	140	132	-	96	93	130	123	348	130

24	112	[illegible]	92x	30	17•	-	154	20x	51	128	137	200x	147	137	150	160	165	141	-	150	142	98	98	21	419
25	57	20•	13	43	18•	-	147	76x F	141 E	132	153	201x F	157	151	160	172	175	154	-	140	137	113	110	25 Top inside window	440 Top outside window
26 (S)	82	92	94	102	100	-	100	113	95	106	76	114	96	95	104	104	110	104	-	78	74	98	96	274	105
(F) Avg	88	15	100	108	108	-	105	120	102	113	103	120	101	100	108	109	115	108	-	80	77	104	100	269	114
27 (S)	70	102	104	112	112	-	110	125	106	8	108	124	105	104	112	113	119	113	-	82	80	108	104	281	115
(F) Avg	70	104	107	-	114	-	111	129	98	121	108	127	104	103	113	114	120	112	-	83	81	111	106	280	116
28 (S)	92	94	108	118	116	-	13	131	0	122	0	130	106	105	115	116	121	114	-	84	82	113	108	290	117
(F) Avg	13	97	110	120	118	-	116	132	3	125	113	132	109	107	118	118	124	116	-	86	84	115	100	288	119
29 (S)	95	109	112	122	120	-	7	134	115	128	114	133	110	109	119	120	126	119	-	86	84	117	112	300	119
(F) Avg	17	112	15	124	23	-	120	138	118	131	118	136	114	112	122	124	129	122	-	90	87	120	115	300	120
30 (S)	98	2	[illegible]	125	125	-	24	142	120	132	118	138	114	112	122	124	129	121	-	88	85	120	115	313	122
(F) Avg	98	2	16	22	24	-	21	140	120	131	118	138	114	112	123	125	130	122	-	90	88	121	115	312	124
31 (S)	100	114	119	127	127	-	125	143	122	134	121	140	116	115	126	128	132	125	-	91	89	123	118	314	122
(F) Avg	102	7	120	130	130	-	128	147	124	137	123	144	118	118	128	131	134	127	-	94	91	126	120	318	125
32 (S)	102	117	21	32	131	-	130	149	127	139	124	144	120	118	130	131	137	128	-	94	91	127	121	328	126
(F) Avg	101	[illegible]	121	132	130	-	126	145	125	137	122	144	118	116	128	128	134	126	-	92	90	125	119	326	128
33 (S)	102	18	122	133	131	-	128	148	126	138	124	146	118	117	130	131	135	127	-	93	91	126	121	344	129
(F) Avg	105	122	126	135	135	-	131	152	130	142	127	149	122	121	133	135	140	132	-	96	93	130	123	348	130
34 (S)	108	122	126	138	135	-	132	153	132	144	128	150	123	121	135	136	142	132	-	96	94	131	126	346	130
(F) Avg	15	122	127	38	135	-	133	154	132	143	128	151	122	121	135	136	141	132	-	97	94	131	125	350	132
35 (S)	107	124	130	139	138	-	136	157	134	145	130	152	124	123	136	138	142	133	-	97	95	132	126	364	133
(F) Avg	110	128	132	146	143	-	141	162	139	151	135	158	130	128	142	144	150	140	-	100	98	137	131	357	134
36 (S)	14	31	35	148	146	-	144	166	142	154	148	162	133	132	145	146	153	142	-	103	101	140	134	362	135
(F) Avg	111	128	135	146	144	-	142	163	139	150	135	158	127	127	142	143	148	138	-	100	98	138	130	364	136
37 (S)	112	130	137	146	145	-	143	164	142	152	137	160	129	128	143	145	150	140	-	101	100	139	132	371	137
(F) Avg	5	133	139	150	149	-	146	168	143	155	140	164	132	132	146	148	153	143	-	104	102	141	135	385	137
38 (S)	20	139	44	154	54	-	154	172	150	162	146	170	140	138	152	156	159	149	-	109	106	146	140	396	134
(F) Avg	115	134	140	150	50	-	147	170	146	156	140	165	131	131	147	150	154	142	-	104	102	143	135	395	134
39 (S)	[illegible]	33	141	151	150	-	148	170	146	156	140	165	130	130	148	150	154	142	-	104	102	143	135	400	134
(F) Avg	114	34	42	150	150	-	149	170	148	156	140	165	130	130	148 FAILURE	150	154	142	-	103	100	143	135	404	135
40 (S)	[illegible]	37	143	156	154	-	153	176	151	163	145	171	137	137	150	156	160	148	-	106	104	146	140	410	136
(F) Avg	119	138	145	157	156	-	153	175	151	162	144	172	137	137	148	156	161	150	-	108	106	148	142	409	137

2

Table VI - Thermocouple Data - Pilot Testing and Test No. 1 - Sheet 4

5	Lower Left Inside Window	Lower Left Outside Window	Lower Right Inside Window	Lower Right Outside Window	Center Inside Window	Center Outside Window	Fwd Mid Hoop 45° LT	Aft Mid Hoop 45° LT	Fwd Mid Hoop 45° RT	Aft Mid Hoop 45° RT
	3	4	5	6	7	8	Outside 9	Outside 10	Outside 11	Outside 12
No 1	-	-		-	-	-	-	-	-	-
No 2	-	-	-	-	-	-	-	-	-	-
No. 8		-		-	-	-	141	145	141	141
No 3			-	-	-	-	-	-	-	-
No 4	-		-	-	-	-	-	-	-	-
No 5	-		-	-	-	-	-	-	-	-
No 6	-		-	-	-	-	-	-	-	-
No 7	-		-	-	-	-	-	-	-	-
No 9	-		-	-		-	234	242	236	237
No 0	-	-	-	-	-	-	-	-	-	-
No 11	-	-	-	-	-	-	238	245 x	239	239
No 12	-	-	-	-	-	-	242	253 x	241	244
No 13	-	-	-	-	-	-	244	246	244	242
No 14	-	-	-	-	-	-	305	308	300	305
15							260 x	268 x	OPEN	261 x
16							273 x	281 x	"	274 x
17							278 x	287 x	"	280 x
18	-	-	-	-	-	-	288	302 x	"	294
19			-	-		-	303	315 x	"	307 x
20							308	320 x	"	310 x
21	-	-			-	-	318 x	329 x	"	320 x
22	-		-	-		-	331 x	343 x		334 x
23				-	-		344 x	355 x		345 x
24				-			362 x	F=S 368 x		F=S 356 x
25	-		-	-		-	391 x	392 x F	"	379 F
26 (S)	258	78	280	118	278	112	254	260	264	255
(F)	260	103	280	120	277	120	260	262	266	259
Avg										
27 (S)	270	103	283	122	288	120	268	270	273	266
(F)	270	104	292	124	288	121	272	274	277	270
Avg										
28 (S)	279	04	300	124	296	122	279	280	283	276
(F)	279	04	300	125	296	124	282	292	286	290
Avg										
29 (S)	286	105	306	126	303	13	288	290	295	288
(F)	290	104	310	27	308	14	294	295	297	292
Avg										
30 (S)	300	106	318	28	3.5	25	300	300	305	299
(F)	300	108	321	30	321	127	306	306	308	303
Avg										
31 (S)	302	07	322	30	323	28	310	310	312 355	307
(F)	305	08	325	32	325	129	311	311	OPEN	308
Avg										
32 (S)	300	100	330	35	328	130	316	316	322	313
(F)	312	111	334	38	334	32	321	320	OPEN	316
Avg										
33 (S)	322	2	342	140	341	32	328	328	382	326
(F)	323	2	345	141	346	34	334	334	OPEN	332

23								344	355 F=5		345 F=5
24								362	368		356
25		–		–	–		–	391	392 F		379 =
26	(S)	258	78	280	118	278	112	254	260	264	255
	(F)	260	103	280	120	277	120	260	262	266	259
	Avg										
27	(S)	270	103	293	22	288	120	268	270	273	266
	(F)	270	104	292	124	288	2	272	274	277	270
	Avg										
28	(S)	279	04	300	124	276	22	279	280	283	276
	(F)	279	04	300	125	296	124	282	282	286	290
	Avg										
29	(S)	286	105	306	126	303	23	288	290	295	288
	(F)	290	104	310	127	308	24	294	295	297	292
	Avg										
30	(S)	300	106	318	28	315	25	300	300	305	299
	(F)	300	108	322	30	321	127	306	306	309	303
	Avg										
31	(S)	302	07	322	30	323	28	310	310	312 365 OPEN	307
	(F)	305	08	325	32	325	129	311	311		308
	Avg										
32	(S)	300	100	330	35	328	30	316	316	362 OPEN	313
	(F)	312	111	334	38	334	32	321	320		316
	Avg										
33	(S)	322	2	342	140	341	32	328	328	382 OPEN	326
	(F)	323	112	345	141	346	34	334	334		332
34	(S)	330	114	348	142	349	136	340	340	394 OPEN	343
	(F)	335	117	354	44	358	36	346	345		346
	Avg										
35	(S)	345	5	362	144	364	136	350	350	405 OPEN	352
	(F)	341	118	358	146	364	138	354	352		354
	Avg										
36	(S)	346	118	314	48	372	139	360	359	409 OPEN	360
	(F)	350	19	366	149	374	140	363	361		362
	Avg										
37	(S)	360	122	377	150	387	141	374	372	418 OPEN	374
	(F)	388	116	393	146	396	136	374	373		372
	Avg										
38	(S)	400	18	426	142	408	34	384	382	425 OPEN	384
	(F)	400	116	426	41	406	132	384	382		384
	Avg										
39	(S)	403	18	416	41	417	33	394	392	441 OPEN	394
	(F)	408	118	416	143	416	33	396	394		395
	Avg										
40	(S)	410	23	424	44	424	136	401	397	455 OPEN	398
	(F)	414	121	420	142	420	36	402	399		400
	Avg										

Table VII - Thermocouple Data - Pilot Testing and Test No. 1 - Sheet 5

2

Location in Laminate	Delamination No. 1	2	3	4	5	6
Outboard surface temperature of as cast Plex 55 thermal barrier (measured by thermo-couple)	345°F	326°F	340°F	340°F	352°F	*
Temperature at as cast Plex 55 to F-3 interlayer inter-face (Calculated)	297	270	280	284	282	
Temperature at stretched Plex 55 to F-3 interlayer interface (calculated)	268	235	244	251	244	
Inboard surface temperature of stretched Plex 55 (measured by Thermocouple)	200	153	166	170	150	*

* The No. 6 delamination was not near enough to a thermocouple to accurately estimate the temperature

Table VIII - Comparison of Canopy Face Sheet Temperatures at Time of Failure - Pilot Testing
(Run No. 15 thru No. 25)

Based on the results of the pilot test, and prior to conducting Test No. 1, several changes were incorporated into the refrigeration system in an effort to eliminate the hot spots. Interior baffling was added and adjusted to give better air distribution.

Also, four small centrifugal blower fans were mounted inside the canopy. These fans were situated to create additional air turbulence at the hot spots in the corner and hoop areas of the bulkheads and also along the top aft area of the canopy. Each small fan has a capacity of about 60 CFM and creates an air velocity of about 1300 FPM at a distance of 16 inches from the fan's exhaust nozzle (2500 FPM in exhaust nozzle).

By adding the baffles and fans, it was possible to eliminate a carbon dioxide cooling unit that was experimented with briefly during pilot testing in an attempt to supplement the regular refrigeration system.

I. TEST NO. 1 - GRADIENT TEMPERATURE DESTRUCTION TEST (NO. 8 THERMO-SHIELD CANOPY)

Following in Table IX is a brief chronological test history for Test No. 1. This test was fully instrumented with all strain gages, deflection beams, linear-motion potentiometers and thermocouples.

For instrumentation purposes, the following test sequence was necessary during each 20 minute test run at a given temperature:

(1) start test run at a given temperature

(2) take instrumentation readings at 8.6 psi

(3) take instrumentation readings at zero pressure

Time	Start of Run No.	End of Run No.	Test Oven Temp. (boundry layer air) (°F)	Outboard Surface Temp (°F)	Remarks
9:23 AM	26		310	260	
10:19		26			
10:25	27		320	270	
10:49		27			
10:53	28		330	280	
11:13		28			
11:19	29		345	290	
11:43		29			
11:45	30		355	300	
12:09PM		30			
12:12	31		360	310	
12:36		31			
12:38	32		370	320	
1:00		32			
1:03	33		385	330	
1:26		33			
1:29	34		398	340	
1:52		34			
1:55	35		405	350	
2:09		35			
2:15	36		415	360	
2:39		36			
2:43	37		425	370	
3:07		37			
3:10	38		438	380	
3:32		38			
3:37	39		448	390	
3:58		39			
4:02					est. start of #1 delamination at aft R. edge of hoop
4:10	40		455	400	
4:17					#1 Delam. was first discovered
4:35					#1 Delm. had doubled in area
4:35					three small del. discovered. All about the size of a dime
4:35		40			Stopped test

Table IX - Chronological Test History - Test No. 1 (No. 8 Canopy)

(4) repressurize to 8.6 psi for remainder of test run

(5) near end of test run, take instrumentation readings at 8.6 psi

(6) take instrumentation readings at zero pressure

(7) end test run at a given temperature

(8) re-pressurize until temperature is stabilized for next run

For purposes of simplicity all sequences have been omitted in Table IX except for the start and ending of each test run.

All thermocouple temperatures for Test No. 1 are tabulated in Tables III thru VII on pages 35 thru 39.

Test runs No. 26 thru 40 apply to Test No. 1.

Figure 10 (reference page 34) shows the locations of the initial delaminations in the No. 8 canopy and the degree to which they had progressed at the time testing terminated.

General observations based on correlating all test temperatures for Test No. 1 are itemized on the following page.

Location in Laminate	Delamination No. 1	2	3	4
Outboard surface temperature of as cast Plex 55 thermal barrier (measured) by thermocouple	376	400	396	398
Temperature at as cast Plex 55 to F-3 interlayer interface (Calculated)	300	326	318	322
Temperature at stretched Plex 55 to F-3 interlayer interface (calculated)	254	282	272	277
Inboard surface temperature of stretched Plex 55 (measured by Thermocouple)	148	175	161	172

Table X - Comparison of Canopy Face Sheet Temperatures at Time of Failure - Test No. 1

(1) All delaminations were again seen to originate at the inner face between the outboard as cast Plex 55 face sheet and the F-3 interlayer

(2) The #2, #3, and #4 delaminations occurred at what appears to be small dirt particles. These dirt particles appear to be in the interlayer but could possibly be imbedded in the surface of the as cast Plex 55 face sheet. At any rate, these particles appear to have had a definite bearing on all delaminations experienced thus far in the full size canopy tests, with two exceptions. Both the #1 delamination on the No. 5 canopy and the #1 delamination on the No. 8 canopy were reasonably large when first discovered (because of their locations and the reflections from the lights in these areas). The exact

location of initial failure in these two cases can only be guessed. Although it is possible that both of these delaminations also started at dirt particles, no conclusive evidence is available that this was the case. It is planned to study the dirt particle phenomenon in more detail with the aid of magnifying lenses.

(3) Again, the stretched Plex 55 did not shrink back even though it's inner face temperature in some areas was as high as 280°F with a corresponding inboard surface temperature of 173°F.

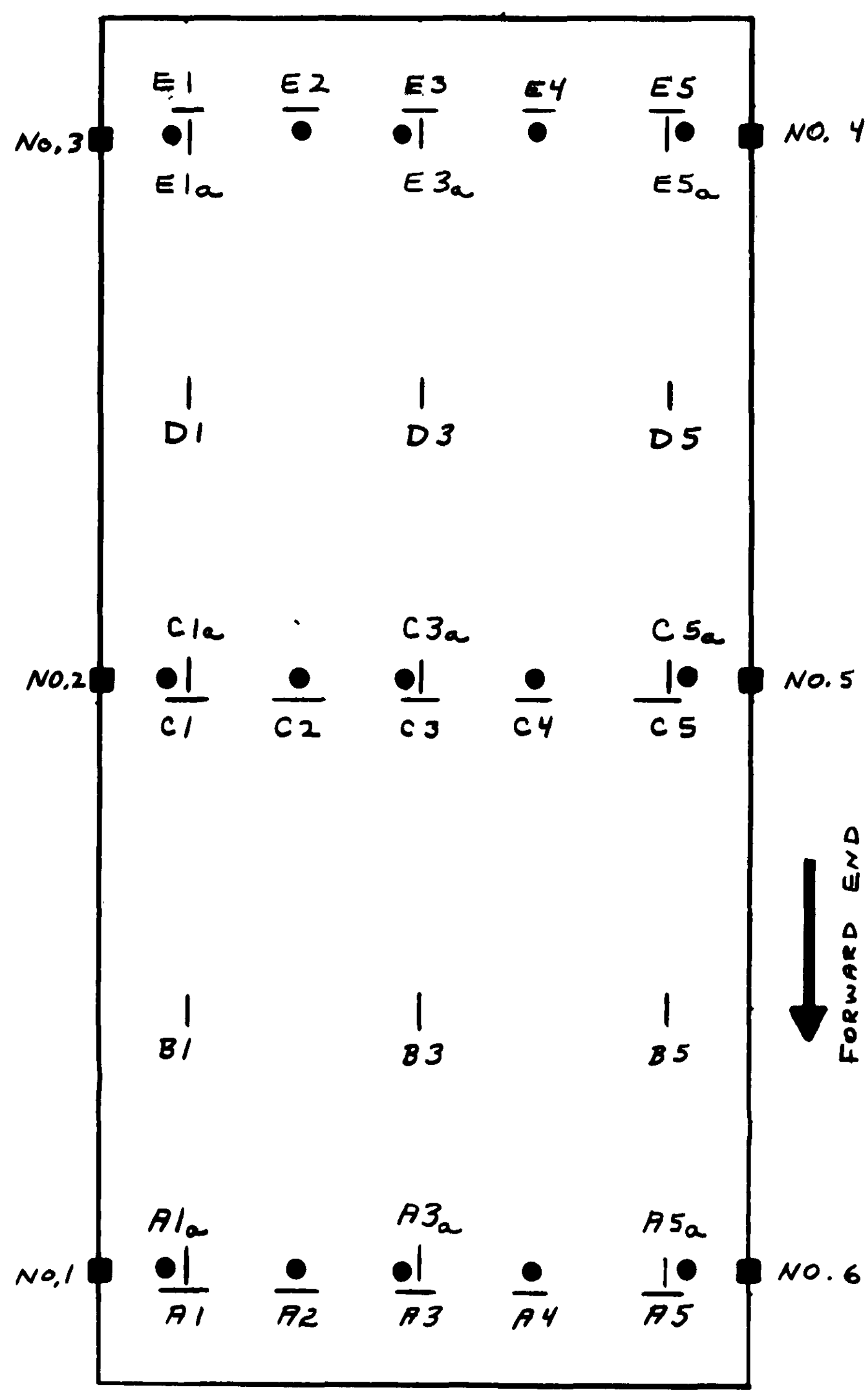
(4) No failure was catastrophic and 8.6 psi pressure was still being maintained in the canopy at the conclusion of testing.

(5) Cooling of the inside of the canopy surface was much improved over the pilot test. This was due to the addition of the four centrifugal blower fans and the adjusting of baffles inside the canopy. It should be emphasized that inboard surface temperatures in the range of 130°-160°F appear to be realistic in magnitude. Accordingly, it has been demonstrated by Test No. 1 that moderately refrigerated air circulated thru the canopy at approximately 390 FPM average velocity and 76 CFM will maintain the inboard boundry layer air (1 inch from surface) in the range of 80 to 100°F. (Reference thermocouple code points 5-6, 5-7, and 5-8).

(6) In both the pilot test and test No. 1, the "as cast" Plex 55 thermal barrier was found to be quite soft and rubbery at the conclusion of testing while the temperature was 400°F or over. The surface could be and was depressed as much as 1/8 inch and no trace of the depressed areas could be found when the canopy had returned to room temperature. The surface of the as cast Plex 55 did not appear in any way to have been damaged by the high temperatures encountered and no orange peel or distortion resulted from the testing and high temperatures and pressures encountered.

J. TEST NO. 1 - STRAIN GAGE, DEFLECTION BEAM AND LINEAR MOTION POTENTIOMETER DATA REDUCTION

Due to the large amount of data to be evaluated and the complexity of the analysis required, only preliminary data has been compiled to date. All information is shown in Tables XI and XII. A schematic diagram showing the relative location of all instrumentation and the identification code is seen in Figure 11. Thus, because of its preliminary nature, no interpetation of the data will be attempted at this time.



Legend

- Baldwin PA-3 post yield strain gages
- cantilever deflection beams
- linear-motion potentiometers

Sign Convention for Data in Tables IX thru XII pages 48 and 49

Bending Beam Data -
With canopy internally pressurized:
movement up + direction
movement down - direction

Potentiometer Data -
Edge of thermal barrier with respect to base:
movement up - direction
movement down + direction

Strain Gage Data -
With canopy internally pressurized:
tension stresses +
compression stresses -

Figure 11. Schematic Diagram Showing Relative Positions of all Strain Gages and Beams, Potentiometers and Code Identification System

[redacted]

REC NO.	REMARKS: SURFACE TEMP °F	PRESS	TIME	A_1	A_{1a}	A_2	A_3	A_{3a}	A_4	A_5	A_{5a}	B_1	B_3	B_5	C_1	C_{1a}	C_2	C_3	C_{3a}	C_4
4	AMB	ON	9:15	[illegible]	-300	300	297	-291	291	[illegible]	-295	-192	0	-194	388	0	396	490	0	324
5	260	ON	BEGIN	194	-100	1600	1881	-291	1068	485	-492	-192	578	194	1068	0	1287	1765	594	757
6	260	OFF	BEGIN	0	200	1100	1287	194	582	311	-295	192	686	485	97	99	693	882	693	324
7		MISC																		
8	260	ON	END	194	-100	1300	1682	-291	874	582	-590	0	588	291	1262	99	1287	1667	495	865
9	260	OFF	END	0	200	700	1187	97	291	291	-295	192	686	582	388	297	792	784	594	433
10	270	ON	BEGIN	388	100	1600	1980	-97	1068	874	-295	192	784	485	1553	297	1485	1667	693	973
11	270	OFF	BEGIN	194	400	900	1287	194	388	485	-98	485	980	777	582	396	891	686	792	541
12	270	ON	END	388	200	1600	1980	-97	874	971	-295	192	980	485	1650	297	1485	1667	792	1189
13	270	OFF	END	194	500	900	1287	194	388	582	0	485	980	777	777	396	891	686	891	649
14	280	ON	BEGIN	388	200	1600	1980	-97	874	971	-393	192	980	485	1747	198	1485	1667	792	1189
15	280	OFF	BEGIN	194	500	1000	1287	194	291	582	-98	485	980	777	777	396	891	686	891	699
16	280	ON	END	388	200	1700	1980	-97	874	971	-295	192	980	485	1844	99	1386	1568	891	1189
17	280	OFF.	END	194	500	900	1287	194	291	582	-98	485	980	777	873	297	891	686	990	699
18	290	ON	BEGIN	388	200	1600	1980	-97	874	971	-295	192	980	485	1844	99	1386	1568	891	1189
19	290	OFF	BEGIN	388	700	1100	1485	388	388	777	98	680	1176	873	1068	495	990	784	1188	757
20	290	ON	END	582	300	1800	2178	-97	874	1165	-295	192	980	582	2639	99	1485	1765	990	1189
21	290	OFF	END	-																
22	300	ON	BEGIN	582	400	1900	2277	97	874	1262	-197	291	1078	679	2039	198	1485	1863	1188	1189
23	300	OFF	BEGIN	388	700	1200	1485	485	291	874	98	680	1274	971	1165	396	1089	882	1188	757
24	300	ON	END	679	400	1900	2376	97	874	1262	-197	192	1078	582	2136	198	1584	1863	1188	1189
25	300	OFF	END	485	800	1300	1584	485	291	971	98	680	1372	971	1359	396	1089	882	1386	757
26	310	ON	BEGIN	777	500	2000	2376	291	964	1359	-98	291	1176	777	2330	198	1584	1863	1188	1297
27	310	OFF	BEGIN	582	900	1300	1682	582	291	971	98	680	1372	971	1359	396	1089	882	1386	757
28	310	ON	END	971	700	2100	2574	291	964	1553	-98	485	1372	873	2330	198	1782	1961	1386	1485
29	310	OFF	END	777	1400	1500	1980	777	485	1262	-295	874	1568	1262	1653	594	1287	1078	1584	973
30	320	ON	BEGIN	971	600	1100	2574	194	874	1456	-98	388	1274	777	2330	198	1782	1863	1386	1189
31	320	OFF	BEGIN	582	900	1400	1782	582	291	1165	-98	777	1470	1165	1456	297	1287	882	1584	757
32	320	ON	END	777	400	2000	2475	194	874	1456	-295	192	1274	679	2330	-99	1782	1765	1287	1189
33	320	OFF	END	582	900	1300	1782	582	194	971	-98	582	1372	971	1359	99	1089	882	1485	649
34	330	ON	BEGIN	777	500	2100	2574	291	874	1456	-197	291	1274	777	2427	-99	1782	1765	1386	1189
35	330	OFF	BEGIN	582	800	1300	1782	582	97	971	-98	582	1372	971	1456	99	1089	686	1386	641
36	330	ON	END	970	500	2199	2574	194	777	1650	-392	388	1176	777	2524	-198	1881	1667	1386	1101
37	330	OFF	END	582	900	1400	1980	582	97	1165	-196	680	1372	971	1456	99	1287	686	1386	501
38	340	ON	BEGIN	970	500	2199	2574	194	680	1553	-490	388	1176	777	2524	-198	1980	1765	1386	1101
39	340	OFF	BEGIN	777	1000	1600	1980	680	194	1262	0	777	1470	1166	1650	99	1485	784	1584	601
40	340	ON	END	582	100	1999	2475	0	388	1359	-882	97	980	388	2427	-693	1782	1274	1188	601
41	340	OFF	END	582	700	1400	1782	582	-97	971	-392	582	1176	777	1553	-297	1287	490	1386	200
42	350	ON	BEGIN	777	200	2099	2574	97	485	1359	-686	194	980	485	2524	-693	1881	1372	1089	701
43	350	OFF	BEGIN	582	700	1500	1881	680	0	971	-294	680	1274	874	1650	-297	1386	490	1485	300
44	350	ON	END	777	100	2099	2377	-97	485	1165	-882	0	784	291	2330	-792	1782	1078	990	501
45	350	OFF	END	582	400	1200	1683	388	-194	777	-490	485	980	582	1359	-693	1089	98	1089	-100
46	360	ON	BEGIN	777	100	2099	2377	0	486	1165	-784	97	784	194	2233	-891	1683	882	990	601
47	360	OFF	BEGIN	485	400	2599	1684	291	-97	682	-490	582	980	582	1456	-693	1089	-98	1089	-100
48	360	ON	END	680	-200	1899	2178	-97	291	971	-882	-291	688	-194	2039	-1386	1386	392	495	300
49	360	OFF	END	388	200	900	1287	388	-388	485	-490	194	784	194	1068	-1089	693	-490	594	100
50	370	ON	BEGIN	777	-400	1799	2377	-194	97	874	-784	-291	588	-194	1942	-1485	1386	294	396	-300
51	370	OFF	BEGIN	582	300	1000	1386	388	-485	582	-392	194	784	194	1262	-1089	693	-490	594	300
52	370	ON	END	970	-200	1300	2178	-97	291	777	-588	-582	588	-388	1845	-1881	891	-294	0	501
53	370	OFF	END	777	300	500	1386	388	-485	582	-294	0	784	0	1068	-1485	99	-1274	198	-300
54	380	ON	BEGIN	1262	100	1699	2377	97	388	1165	-392	-291	688	-194	2039	-1584	1089	-98	198	701
55	380	OFF	BEGIN	970	500	900	1584	680	-194	874	98	194	1176	194	1456	-1188	396	-882	297	100
56	380	ON	END	1165	-100	1500	2178	-97	291	971	-490	-682	784	-485	2233	-1782	1089	-98	-198	601
57	380	OFF	END	777	300	600	1386	388	-291	682	-98	-97	980	-97	1653	-1485	297	-1078	0	-200
58	390	ON	BEGIN	1262	-100	1699	2377	97	485	1166	-392	-485	784	-388	485	198	1689	98	0	701
59	390	OFF	BEGIN	874	300	700	1386	388	-388	582	-98	-97	980	-194	1553	-1485	297	-1078	0	-200
60	390	ON	END	1165	-300	1500	2178	-97	194	971	-490	-582	688	-582	2233	-1881	1089	-294	-297	601
61	390	OFF	END	874	300	500	1287	291	-485	682	-196	-194	784	-291	1553	-1584	99	-1274	-198	-400
62	400	ON	BEGIN	1165	-300	1500	2079	-97	291	971	-490	-582	588	-680	2039	-1881	891	-294	-396	601
63	400	OFF	BEGIN	777	100	400	1188	194	-582	485	-294	-291	784	-388	1456	-1485	99	-392	-297	-400
64	400	ON	END	1165	-300	1500	2079	-97	194	971	-490	-582	490	-680	2039	-1782	1089	-294	-396	+501
65	400	OFF	END	970	200	500	1188	388	-680	582	-196	-194	784	-291	1653	-1485	99	-392	-297	-501
66	ZERO AFTER TEST			388	500	700	594	680	680	388	588	680	686	-582	682	693	693	588	694	601

B_5	C_1	C_{1a}	C_2	C_3	C_{3a}	C_4	C_5	C_{5a}	D_1	D_3	D_5	E_1	E_{1a}	E_2	E_3	E_{3a}	E_4	E_5	E_{5a}
194	388	0	396	490	0	324	882	-196	-98	0	-297	396	-198	213	286	-490	191	485	-191
194	1068	0	1287	1765	594	757	1176	-98	294	1078	-99	792	-693	2232	1524	0	1524	1456	-191
485	97	99	693	882	693	324	98	98	490	1176	99	198	-396	1807	953	686	953	874	0
									392	1176	0	693	-594	2126	1429	196	1429	1456	-191
391	1262	99	1287	1667	495	765	1078	-98	490	882	0	693	-594	2232	1238	-98	1429	1456	-191
572	388	297	792	784	594	433	0	294	686	980	297	198	-396	1807	667	490	953	971	191
485	1553	297	1485	1667	693	973	1176	98	686	1078	297	792	-396	2444	1334	0	1524	1748	95
777	582	396	891	686	792	541	0	392	784	1078	396	198	-198	1807	667	490	953	1068	286
485	1650	297	1485	1667	792	1189	1176	98	686	980	198	792	-594	2551	1238	0	1524	1845	95
777	777	396	891	686	891	649	0	392	784	980	495	198	-297	2019	667	686	953	1262	381
485	1747	198	1485	1667	792	1189	1179	0	588	882	99	792	-693	2537	1143	0	1524	1845	95
777	777	396	891	686	891	649	-98	294	784	980	396	297	-297	2019	667	588	857	1262	381
485	1844	99	1386	1568	891	1189	1078	-98	686	882	99	792	-693	2657	1048	0	1429	1942	95
777	873	297	891	686	990	649	-98	294	784	980	396	297	-396	2019	476	686	857	1456	476
485	1844	99	1386	1568	891	1189	1098	-98	686	882	198	792	-594	2657	1143	0	1524	2039	191
875	1068	495	990	784	1188	757	0	392	882	980	495	396	-198	2232	667	686	953	1553	667
572	2039	99	1485	1765	990	1189	980	0	588	980	99	792	-594	2870	1143	0	1524	2233	191
									882	1078	495	297	-198	2232	572	784	953	1651	667
679	2039	198	1485	1863	1188	1189	1176	98	686	980	198	792	-396	2976	1238	196	1524	2039	667
971	1165	396	1089	882	1188	757	0	392	882	1176	495	396	-198	2444	667	882	953	1651	762
582	2136	198	1584	1863	1188	1189	980	0	686	980	198	792	-693	2976	1048	98	1524	2427	381
971	1359	396	1089	882	1386	757	0	490	882	1176	495	396	-198	2551	572	882	953	1845	762
777	2330	198	1584	1863	1188	1297	1176	98	686	980	198	891	-594	3082	1238	196	1524	2427	476
971	1359	396	1089	882	1386	757	0	392	882	1176	495	396	-198	2444	476	882	953	1845	762
873	2330	198	1782	1961	1386	1465	980	294	784	1078	297	792	-396	3295	1143	294	1715	2621	572
1262	1553	594	1287	1078	1584	973	0	588	980	1176	693	396	-99	2657	476	980	1048	2039	1048
777	2330	198	1782	1863	1386	1189	980	196	686	980	297	792	-594	3296	1048	196	1524	2621	572
1165	1456	297	1287	882	1584	757	-98	392	882	1078	495	297	-198	2657	476	882	857	1845	857
679	2330	-99	1782	1765	1287	1189	882	-196	490	784	0	693	-792	3295	857	0	1334	2621	381
971	1359	99	1089	882	1485	649	-196	294	490	784	198	-99	-594	2651	191	588	572	1748	667
777	2427	-99	1782	1766	1386	1189	882	-196	392	784	0	594	-990	3295	857	0	1334	2621	381
971	1456	99	1089	686	1386	541	-196	98	588	784	297	99	-594	2657	191	686	572	1845	762
777	2524	-198	1881	1667	1386	1101	784	-196	294	588	0	693	-1089	3295	476	-196	1238	2719	381
971	1456	99	1287	686	1386	501	-294	98	490	588	296	-99	-693	2657	-95	490	672	2039	762
777	2524	-198	1980	1765	1386	1101	882	-196	294	588	0	693	-1089	3507	762	-196	1334	2816	476
1166	1650	99	1485	784	1584	601	-196	98	294	588	296	0	-594	3826	0	490	667	2427	476
388	2427	-693	1782	1274	1188	601	490	-588	-196	0	-495	99	-1386	3082	191	-490	857	2621	95
777	1553	-297	1287	490	1386	200	-392	-196	98	196	-99	-396	-990	2444	-476	196	95	2136	286
485	2524	-693	1881	1372	1089	701	588	-490	-196	98	-296	196	-1287	3188	286	-490	857	2719	95
874	1650	-297	1386	490	1485	300	-294	-98	98	294	0	-294	-891	2444	-381	294	191	2039	572
291	2330	-792	1782	1078	990	501	490	-490	-294	0	-594	196	-1386	2976	191	-490	667	2621	-191
582	1359	-693	1089	98	1089	-100	-490	-98	-98	98	-296	-196	-891	2232	-667	196	-95	1845	191
194	2233	-891	1683	882	990	601	490	-490	-294	0	-693	196	-1188	2870	191	-490	667	2427	-191
582	1456	-693	1089	-98	1089	-100	-588	-98	-98	98	-296	-396	-891	2126	-667	294	-286	1845	191
-194	2039	-1386	1386	392	495	300	196	-588	-490	0	-990	99	-1386	2657	-95	-490	[illegible]	2233	-667
194	1068	-1089	693	-490	594	100	-784	-196	-294	98	-792	-588	-1089	1913	-1048	294	-667	1359	-476
-194	1942	-1485	1386	294	396	-300	98	-490	-490	0	-1188	99	-1386	2657	-191	-490	191	1942	-857
194	1262	-1089	693	-490	594	300	-784	-98	-196	196	-792	-396	-990	1807	-1143	392	-667	1262	-476
-388	1845	-1881	891	-294	0	501	98	-294	-294	392	-1287	-396	-1386	2657	-476	-98	0	1651	-953
0	1068	-1485	99	-1274	198	-300	-784	+294	-294	588	-891	0	-990	1807	-1429	882	-853	1262	-572
-194	2039	-1584	1089	-98	198	701	294	-98	0	588	-1089	693	-1188	2870	-286	196	191	1845	-762
194	1456	-1188	396	-882	297	100	-490	490	392	294	-693	99	-792	2019	-1238	980	-762	1068	-381
-485	2233	-1782	1089	-98	-198	601	196	294	-196	392	-1287	396	-1386	2763	-476	-98	95	1748	-1048
-97	1653	-1485	297	-1078	0	-200	-588	-294	98	588	-891	-196	-990	1807	-1429	882	-857	874	-762
-388	485	198	1089	98	0	701	392	-294	-98	294	-1287	490	-1287	2763	-476	-98	191	1748	-1143
-194	1653	-1485	297	-1078	0	-200	-588	-294	98	490	-891	-196	-990	1807	-1524	784	-953	874	-762
-582	2233	-1881	1089	-294	-297	601	588	-490	-392	0	-1485	196	-1386	2657	-667	-294	-95	1651	-1238
-291	1553	-1584	99	-1274	-198	-400	-686	-98	0	294	-1089	-294	-1188	213	-476	678	-95	777	-857
-680	2039	-1881	891	-294	-396	601	0	-490	-294	0	-1386	396	[illegible]	2444	-667	-294	0	-1651	-1238
-388	1456	-1485	99	-392	-297	-400	-784	-98	0	196	-990	-294	-1188	1382	-1810	490	-286	777	-857
-680	2039	-1782	1089	-294	-396	+501	0	-490	-196	0	-1287	588	-1386	2338	-667	-490	95	1748	-1238
-291	1553	-1485	99	-392	-297	-501	-784	196	-294	196	-891	-99	-990	1382	-1965	490	-1143	874	[illegible]
-582	582	693	693	588	594	601	588	686	686	688	495	588	594	531	476	490	476	[illegible]	572

Table XI - Strain Gage Preliminary Data - Test No. 1
(all data in micro inches per inch)

GER 10631

OSC REC NO	Surface Temp °F	Pressure	Time	A	A2	A3	A4	A5	C1	C2	C3	C4	C5	E1	E2	E3	E4	E5	Pot 1	Pot 2	Pot 3	Pot 4	Pot 5	Pot 6	Pressure PSI
4	AMB	OFF		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.03
5	AMB	ON	9:15	-.02	.03	-.03	-.03	-.03	-.02	-.04	-.04	-.05	0	-.01	-.04	-.06	-.05	-.02	0	0	0	0	0	0	8.8
6	260	ON	BEGIN	-.05	-.05	-.06	-.05	-.06	-.04	-.05	-.07	-.08	-.01	-.04	-.11	-.12	-.09	-.03	0	0	0	0	0	0	8.7
7	260	OFF	BEGIN	-.05	.03	-.03	-.02	-.04	-.04	-.06	-.03	-.04	-.03	-.03	-.05	-.07	-.05	-.02	0	0	0	0	0	0	.03
8	260	ON	END	[illegible]	-.05	[illegible]	[illegible]	-.05	-.04	-.09	-.06	-.08	-.02	-.03	-.09	-.11	-.09	-.03	0	0	0	0	0	0	8.7
9	260	OFF	END	-.05	-.03	-.03	-.02	-.04	-.04	-.06	-.04	-.03	-.03	-.03	-.06	-.07	-.05	-.02	0	0	0	0	0	0	.03
10	270	ON	BEGIN	-.04	-.05	-.05	-.05	-.05	-.04	-.07	-.06	-.08	-.02	-.04	-.09	-.12	-.09	-.03	0	0	0	0	0	0	8.7
11	270	OFF	BEGIN	-.05	-.03	-.03	-.01	-.03	-.03	-.05	-.03	-.02	-.03	-.03	-.05	-.06	-.05	-.02	0	0	0	0	0	0	.07
12	270	ON	END	-.05	-.06	-.06	-.05	-.05	-.04	-.09	-.07	-.08	-.02	-.04	-.10	-.11	-.09	-.03	0	0	0	0	0	0	8.2
13	270	OFF	END	-.03	-.03	-.03	-.02	-.04	-.04	-.06	-.03	-.03	-.03	-.03	-.07	-.06	-.05	-.02	0	0	0	0	0	0	.03
14	280	ON	BEGIN	-.05	-.05	-.06	-.05	-.05	-.04	-.08	-.07	-.08	-.01	-.02	-.08	-.11	-.09	-.03	-.01	-.03	-.02	-.03	-.04	-.01	8.6
15	280	OFF	BEGIN	-.03	-.03	-.03	-.01	-.03	-.04	-.06	-.03	-.03	-.03	-.03	-.05	-.06	-.05	-.02	.01	-.01	.01	0	-.02	.01	.07
16	280	ON	END	-.04	-.05	-.06	-.05	-.05	-.03	-.08	-.07	-.08	-.03	-.03	-.10	-.11	-.09	-.03	-.01	-.03	-.02	-.03	-.04	-.01	8.5
17	280	OFF	END	-.03	-.04	-.04	-.01	-.03	-.03	-.06	-.04	-.03	-.03	-.03	-.06	-.06	-.05	-.02	.01	-.02	0	0	-.03	.01	.03
18	290	ON	BEGIN	-.05	-.06	-.06	-.05	-.05	-.04	-.08	-.07	-.07	-.01	-.03	-.10	-.11	-.09	-.03	-.01	-.03	-.02	-.03	-.04	-.01	8.6
19	290	OFF	BEGIN	-.03	-.03	-.07	-.02	-.03	-.03	-.06	-.04	-.03	-.03	-.03	-.06	-.06	-.05	-.02	.01	-.01	.01	0	-.03	.01	.03
20	290	ON	END	-.05	-.06	-.06	-.05	-.05	-.03	-.08	-.07	-.08	-.02	-.04	-.09	-.12	-.09	-.03	-.01	-.04	-.03	-.03	-.05	-.01	8.4
21	290	OFF	END	-.03	-.04	-.04	-.01	-.04	-.03	-.06	-.03	-.03	-.03	-.03	-.05	-.06	-.05	-.02	.01	-.02	0	-.01	-.03	.01	.07
22	300	ON	BEGIN	-.05	-.06	-.06	-.05	-.05	-.03	-.08	-.07	-.08	-.02	-.03	-.08	-.10	-.09	-.03	-.01	-.04	-.02	-.03	-.05	-.01	8.4
23	300	OFF	BEGIN	-.03	-.04	-.04	-.01	-.04	-.03	-.06	-.03	-.03	-.03	-.03	-.06	-.06	-.05	-.02	.01	-.02	0	-.01	-.03	.01	.07
24	300	ON	END	-.05	-.06	-.06	-.05	-.05	-.04	-.08	-.07	-.11	-.02	-.03	-.09	-.11	-.09	-.03	-.01	-.04	-.03	-.04	-.05	-.01	8.6
25	300	OFF	END	-.03	-.04	-.04	-.02	-.04	-.03	-.07	-.04	-.04	-.03	-.03	-.06	-.06	-.05	-.02	.01	-.02	0	-.01	-.03	.01	.03
26	310	ON	BEGIN	-.05	-.06	-.06	-.05	-.05	-.03	-.08	-.07	-.09	-.02	-.03	-.09	-.11	-.09	-.03	-.01	-.04	-.03	-.04	-.05	-.01	8.6
27	310	OFF	BEGIN	-.03	-.04	-.04	-.02	-.04	-.03	-.07	-.04	-.04	-.03	-.03	-.06	-.06	-.05	-.02	.01	-.02	0	-.01	-.03	.01	.07
28	310	ON	END	-.05	-.07	-.06	-.05	-.05	-.04	-.08	-.07	-.09	-.02	-.04	-.09	-.11	-.09	-.03	-.01	-.04	-.03	-.04	-.05	-.01	8.7
29	310	OFF	END	-.03	-.04	-.04	-.02	-.04	-.03	-.07	-.03	-.04	-.03	-.03	-.06	-.06	-.05	-.02	0	-.02	-.01	-.01	-.03	.01	.07
30	320	ON	BEGIN	-.05	-.07	-.07	-.06	-.05	-.03	-.08	-.06	-.09	-.02	-.04	-.09	-.11	-.09	-.03	-.01	-.04	-.03	-.04	-.05	-.01	8.5
31	320	OFF	BEGIN	-.03	-.04	-.04	-.02	-.04	-.03	-.07	-.03	-.04	-.03	-.03	-.06	-.06	-.05	-.02	.01	-.02	-.01	-.01	-.03	.01	.07
32	320	ON	END	-.05	-.07	-.07	-.06	-.06	-.04	-.08	-.07	-.10	-.02	-.04	-.09	-.11	-.09	-.03	-.01	-.04	-.03	-.03	-.05	-.01	8.6
33	320	OFF	END	-.03	-.04	-.04	-.02	-.04	-.03	-.08	-.03	-.04	-.03	-.03	-.06	-.06	-.05	-.02	.01	-.03	-.01	-.01	-.04	.01	.07
34	330	ON	BEGIN	-.04	-.05	-.06	-.05	-.05	-.03	-.07	-.06	-.09	-.01	-.03	-.08	-.09	-.08	-.02	-.01	-.04	-.03	-.04	-.05	-.01	8.6
35	330	OFF	BEGIN	-.03	-.04	-.04	-.01	-.04	-.03	-.08	-.03	-.04	-.01	-.03	-.06	-.06	-.05	-.02	.01	-.02	0	-.01	-.03	.01	.10
36	330	ON	END	-.05	-.07	-.07	-.06	-.05	-.03	-.08	-.07	-.10	-.02	-.04	-.10	-.11	-.10	-.03	-.01	-.04	-.03	-.04	-.05	-.01	8.7
37	330	OFF	END	-.03	-.05	-.05	-.02	-.04	-.03	-.08	-.03	-.05	-.03	-.03	-.07	-.06	-.06	-.02	0	-.03	-.01	-.01	-.03	0	.07
38	340	ON	BEGIN	-.05	-.07	-.07	-.06	-.06	-.04	-.08	-.06	-.10	-.02	-.04	-.10	-.10	-.10	-.03	-.01	-.04	-.03	-.03	-.05	-.01	8.6
39	340	OFF	BEGIN	-.03	-.05	-.05	-.02	-.04	-.03	-.07	-.02	-.05	-.03	-.03	-.07	-.06	-.06	-.02	0	-.02	-.01	-.01	-.03	.01	.07
40	340	ON	END	-.06	-.07	-.07	-.06	-.06	-.04	-.08	-.06	-.11	-.02	-.04	-.10	-.11	-.10	-.03	-.01	-.04	-.03	-.03	-.05	-.01	8.7
41	340	OFF	END	-.03	-.05	-.04	-.02	-.04	-.03	-.08	-.01	-.06	-.03	-.03	-.07	-.04	-.06	-.02	0	-.03	-.01	-.01	-.03	.01	.07
42	350	ON	BEGIN	-.05	-.08	-.07	-.06	-.06	-.04	-.08	-.05	-.11	-.02	-.04	-.10	-.10	-.09	-.03	-.01	-.04	-.03	-.04	-.05	-.01	8.4
43	350	OFF	BEGIN	-.03	-.05	-.05	-.02	-.04	-.03	-.07	-.01	-.06	-.03	-.03	-.07	-.04	-.05	-.02	.01	-.03	-.01	-.01	-.03	.01	.07
44	350	ON	END	-.05	-.07	-.07	-.06	-.06	-.04	-.07	-.05	-.11	-.02	-.04	-.10	-.10	-.09	-.04	-.01	-.04	-.03	-.03	-.05	-.01	8.6
45	350	OFF	END	-.04	-.05	-.05	-.03	-.04	-.03	-.08	0	-.07	-.03	-.03	-.07	-.04	-.06	-.03	0	-.03	-.01	-.01	-.04	0	.07
46	360	ON	BEGIN	-.05	-.08	-.08	-.07	-.06	-.04	-.07	-.05	-.12	-.02	-.05	-.11	-.10	-.10	-.04	-.01	-.05	-.04	-.04	-.05	-.01	8.5
47	360	OFF	BEGIN	-.04	-.05	-.05	-.03	-.04	-.03	-.07	0	-.07	-.03	-.03	-.07	-.04	-.06	-.03	0	-.03	-.01	-.01	-.04	0	.07
48	360	ON	END	-.05	-.07	-.07	-.06	-.05	-.04	-.07	-.04	-.12	-.02	-.05	-.10	-.10	-.09	-.04	-.01	-.04	-.03	-.03	-.05	-.01	8.4
49	360	OFF	END	-.04	-.05	-.05	-.02	-.02	-.03	-.07	.01	-.08	-.03	-.04	-.07	-.03	-.06	-.03	0	-.03	-.01	-.01	-.04	0	.07
50	370	ON	BEGIN	-.05	-.08	-.07	-.06	-.06	-.04	-.07	-.04	-.12	-.02	-.05	-.10	-.10	-.09	-.04	-.01	-.04	-.03	-.03	-.05	-.01	8.5
51	370	OFF	BEGIN	-.04	-.05	-.05	-.03	-.04	-.03	-.07	.02	-.08	-.03	-.03	-.07	-.03	-.05	-.03	0	-.03	-.01	-.01	-.03	0	.07
52	370	ON	END	-.05	-.08	-.08	-.06	-.05	-.04	-.07	-.04	-.13	-.02	-.05	-.10	-.10	-.10	-.04	-.02	-.05	-.04	-.04	-.05	-.01	8.5
53	370	OFF	END	-.03	-.05	-.05	-.03	-.03	-.02	-.07	.02	-.08	-.02	-.03	-.07	-.03	-.05	-.03	.01	-.03	-.01	0	-.03	.01	.10
54	380	ON	BEGIN	-.05	-.07	-.07	-.06	-.05	-.04	[illegible]	-.03	-.12	-.02	-.05	-.10	-.10	-.09	-.04	-.01	-.05	-.03	-.03	-.04	-.01	8.4
55	380	OFF	BEGIN	-.04	-.05	-.05	-.03	-.03	-.02	-.07	.02	-.08	-.02	-.03	-.07	-.03	-.06	-.03	0	-.03	-.01	-.01	-.04	0	.07
56	380	ON	END	-.06	-.08	-.08	-.06	-.05	-.04	-.07	-.04	-.13	-.02	-.05	-.10	-.11	-.09	-.04	-.01	-.05	-.03	-.01	-.04	-.01	8.3
57	380	OFF	END	-.04	-.05	-.05	-.03	-.03	-.02	-.07	.02	-.10	-.02	-.05	-.07	-.03	-.05	-.03	0	-.04	-.01	-.01	-.04	0	.07
58	390	ON	BEGIN	-.06	-.08	-.08	-.07	-.06	-.04	-.08	-.05	-.14	-.02	-.03	-.10	-.11	-.10	-.04	-.01	-.05	-.03	-.01	-.05	-.01	8.6
59	390	OFF	BEGIN	-.04	-.06	-.05	-.03	-.04	-.02	-.07	.02	-.10	-.01	-.05	-.07	-.03	-.05	-.03	0	-.04	-.02	-.01	-.04	0	.07
60	390	ON	END	-.05	-.07	-.07	-.06	-.05	-.03	-.07	-.04	-.14	-.01	-.05	-.10	-.10	-.09	-.04	-.01	-.05	-.03	-.01	-.05	-.01	8.4
61	390	OFF	END	-.03	-.05	-.05	-.03	-.03	-.02	-.07	.03	-.10	-.01	-.04	-.07	-.03	-.05	-.03	0	-.04	-.04	-.01	-.04	0	.07
62	400	ON	BEGIN	-.05	-.07	-.07	-.06	-.05	-.03	-.07	-.04	-.14	-.01	-.05	-.10	-.09	-.09	-.04	-.01	-.05	-.03	-.01	-.05	-.01	8.6
63	400	OFF	BEGIN	-.03	-.05	-.05	-.03	-.03	-.01	-.07	.03	-.10	-.01	-.04	-.07	-.02	-.05	-.03	0	-.04	-.01	-.01	-.04	0	.07
64	400	ON	END	-.06	-.08	-.08	-.06	-.05	-.03	-.07	-.05	-.14	-.01	-.05	-.10	-.10	-.10	-.04	-.01	-.06	-.04	-.03	-.05	-.01	8.7
65	400	OFF	END	-.03	-.06	-.05	-.03	-.03	-.01	-.07	.03	-.10	-.01	-.03	-.07	-.02	-.06	-.03	0	-.04	-.01	-.01	-.04	0	.07

Table XII - Beam Deflection and Potentiometer Preliminary Data - Test No. 1
(all data in inches)

SECTION III - WORK SCHEDULED FOR NEXT PERIOD

A. Phase I

1. All work completed.

B. Phase II

1. Laminate one side panel using sheet interlayer and autoclave pressures.

C. Phase III

1. Conduct Test No. 1 - second half gradient temperature destruction test starting at 300°F.
2. Conduct long time cyclic test.
3. Reduce all test data from Phase III.
4. Prepare Final Program report.
5. Package and ship all required contract items to BuWeps.

LIST OF REFERENCES

1. GER-10378 "Evaluation of High-Temperature Cast-In-Place Transparent Plastics Laminates Suitable for Canopies on Supersonic Fighter Aircraft" Progress Report No. 7, 8 November 1960 through 8 February 1961.

2. GER-10379 "Evaluation of High-Temperature Cast-In-Place Transparent Plastic Laminates Suitable for Canopies on Supersonic Fighter Aircraft." Progress Report No. 8, 9 February 1961 through 8 May 1961.

3. GAP - 8225 "Proposed Program to Evaluate High-Temperature Cast-in-Place Transparent Plastic Laminates Suitable for Canopies on Supersonic Fighter Aircraft", 31 December 1958.